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Contents

Symposium—Heating Rates of Steel for Various Operations—by A. J. Fisher, S. F. Magis, Martin J. Conway, and T. A. Lewis 13

DISCUSSION—Symposium—Heating Rates of Steel for Various Operations—Presented by L. F. Coffin, A. J. Fisher, M. J. Conway, W. Paul Gerhart, G. B. McMeans, M. J. Bradley, Louis Moses, and T. A. Lewis 21

American Cast Iron Pipe Company 24

Report of Educational Program Committee, Detroit Section, A. I. & S. E.—by L. R. Milburn 26

Tin Plate Production at the Tennessee Coal, Iron and Railroad Company—by T. J. Ess, assisted by James D. Kelly T 1

Official Program, A. I. & S. E. Annual Spring Conference 29

Performance of Blooming Mill Auxiliary Drives with Ward-Leonard Control—by W. A. Perry, Superintendent, Electrical and Power Departments, Inland Steel Company; and W. B. Snyder, Industrial Department, General Electric Company 42

DISCUSSION—Performance of Blooming Mill Auxiliary Drives with Ward-Leonard Control—Presented by A. M. MacCutcheon, F. R. Burt, R. H. Ellis, I. N. Tull, W. A. Perry, C. J. Porter, R. G. Widdows, and James Farrington 48

Republic Steel Corporation, Gulfsteel Division 52

Latest Design and Equipment for the Industry 61

Items of Interest 68

Index to Advertisers 9

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Symposium

HEATING RATES of STEEL for VARIOUS Operations

"Heating Rates of Strip Steel and Tin Plate Products"

A. J. FISHER, Fuel Engineer, Bethlehem Steel Company, Sparrows Point, Md.

"Soaking Pit Heating Rates for Cold Ingots"

MARTIN J. CONWAY, Fuel Engineer, Lukens Steel Co., Coatesville, Penna.

"Heating Rates for Processing Alloy Steels"

S. F. MAGIS, Steel Works Metallurgist, Henry Disston and Sons, Inc., Philadelphia, Pennsylvania.

"Heating for Forgings"

T. A. LEWIS, Combustion Engineer, Bethlehem Steel Company, Bethlehem, Pennsylvania.

DISCUSSION PRESENTED BY

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PRESENTED BEFORE A. I. & S. E. PHILADELPHIA SECTION, NOV. 5, 1938

HEATING RATES of STRIP STEEL and TIN PLATE PRODUCTS

By A. J. FISHER, Fuel Engineer
BETHLEHEM STEEL CO.
SPARROWS POINT, MD.

▲ THE heating of strip steel and tin plate products, because of their low carbon content, can be done in comparatively short time cycles.

Nowhere in the heating of steel is it more important to have carefully regulated fuels than in the making of sheets and tin plate products. The surface of the sheets are very large in proportion to their weight, and they must be smooth and free from all defects.

The important heating items to safeguard in the making of flat products are as follows:

1. Uniformity of heating.
2. Accurate temperatures.
3. Controlled atmospheres.

Defects from improper heating or furnace design are as follows:

1. Burned edges of slabs which cause ragged edges of the strip or sheets.
2. Rolled in furnace refractories.
3. Scratches from furnace conveyors.
4. Carbon deposits from furnace atmospheres.
5. Burned edges from leaky annealing covers.
6. Sulphur deposits from furnace atmospheres.
7. Warped edges from too fast heating in the annealing cycle.

The heating rates of the various furnaces in our operations are shown by Table 1. for oil fired furnaces and by Table 2, for gas fired furnaces.

These rates are all based on practice and can be used by the furnace designer and fuel engineer.

TABLE 1
HIGHEST AVERAGE HEATING RATES OF OIL FIRED FURNACES

Kind of heating	(1) Size of material heated	(2) Method of charging	(3) Sq. ft. of hearth area	(4) Btu. per hr. per sq. ft. hearth area	(5) Charging and discharging temperatures degrees F.	(6) Lb. steel per hour per sq. ft. of hearth area	(7) Time in the furnace
Slab heating for hot strip.	4½"x30"x180"	Flat	1435	63,600	70–2300	70.80	106 min.
Slab heating for sheets...	2"x12"x60"	Flat piles	245	55,800	70–2300	30.60	120 "
Pair heating for sheets....	.36"x12"x36"	Flat	522	21,900	70–1450	30.10	17 "
Pair heating for sheets....	.36"x12"x36"	Edge	76	60,000	70–1450	65.00	150 "
Box annealing—sheets....	24 gauge	Flat	159	67,000	70–1300	8.37	40 hrs.
Box annealing—tin plate..	30 gauge	Flat	210	39,900	70–1100	11.65	12 "

TABLE 2
HIGHEST AVERAGE HEATING RATES OF GAS FIRED FURNACES

Kind of heating	Size of material heated	Method of charging	Sq. ft. of hearth area	Btu. per hr. per sq. ft. hearth area	Charging and discharging temperatures degrees F.	Lb. steel per hour per sq. ft. hearth area	Time in the furnace
Pair heating—tin plate....	.34"x8"x30"	Edge	32	22,000	70–1400	54.60	150 min.
Pack heating—tin plate...	30 gauge	Flat	76	14,500	500–1400	46.00	15 "
Pack heating—sheets.....	24 gauge	Flat	296	14,200	300–1500	19.00	6 "
Pack heating—sheets.....	24 gauge	Flat	373	13,700	300–1500	18.00	6 "
Normalizing—sheets.....	16 gauge	Flat	600	26,000	70–1750	28.00	7 "
Normalizing—tin plate....	30 gauge	Flat	429	21,000	70–1750	23.00	12 "
Box annealing—sheets.....	16 gauge	Flat	120	25,000	70–1125	26.00	65 hrs.
Box annealing—tin plate..	30 gauge	Coils on edge	215	18,600	70–1280	26.00	36 "

SOAKING PIT HEATING RATES for COLD INGOTS

by M. J. CONWAY, Fuel Engineer, Lukens Steel Co.

▲ THE problem of heating rates for cold ingots is one having many angles depending on the size and shape of the ingots and their composition. The time necessary to bring hot steel to the required rolling temperature is approximately the same amount of the time as the interval between the time the heat was tapped and the time it was charged into the pits, and, with the exception of scale thickness, control of the heating operation is comparatively simple.

Of course, I am not minimizing the importance of correct even heating of the ingot immaterial of its temperature when charged. Injury can be caused by underheating, overheating, uneven heating, or burning. Of the foregoing, underheating and overheating are the least harmful to the steel; underheating increases the amount of power required for rolling with the consequent loss of the piece due to its not making the correct gauge; overheating by increasing the grain size and lowering the force of cohesion is likely to cause cracking in the piece being rolled.

Uneven heating increases the hazards and delays due to broken rolls, etc. Burning or extreme overheating to a temperature just below the melting point, causing the more fusible constituents to melt and run out of the ingot, forming cavities, is the least excusable of the ingot heating injuries, as it usually results in a total rejection.

We have made the usual heating time determinations by inserting thermocouples into the ingot to various depths and from the information so collected, have determined the time required for the center of various sizes of ingots to reach equilibrium with the outside ingot temperature when that temperature is correct for rolling, we have set up an arbitrary or average heating time for most of our operations to a minimum of 30 minutes per one inch of ingot thickness, or a 6 hour heating time minimum for a cold ingot 12 inches thick, heated to 2350 degrees F. throughout. This time-temperature heating cycle agrees closely with work done by other investigators and numerous charts are available in technical literature supporting our conclusions.

However, ideal plasticity of the metal is dependent on the heating time that produces a fairly straight heating gradient line in the center of the ingot without undue punishment to the outside of the ingot. This theory is expressed in other words in a recent article on "Blast Furnace Gas for Heating Ingots" at the Hamilton plant of the Steel Company of Canada. Referring to hot ingot practice, the article states, "Ingot heating is generally performed with too little consideration of the steel's ability to absorb heat. There is a high rate of firing, when using high Btu. fuels, simply because it is possible and easy to do. The use of rich fuels may be regarded as inducing too rapid a heating.

"To obtain sound heating practice, it may be necessary for the industry to divorce itself from the conception that ingots, particularly the larger ingots in current

FIGURE 1—Method of application of fuel oil firing to a regenerative soaking pit.

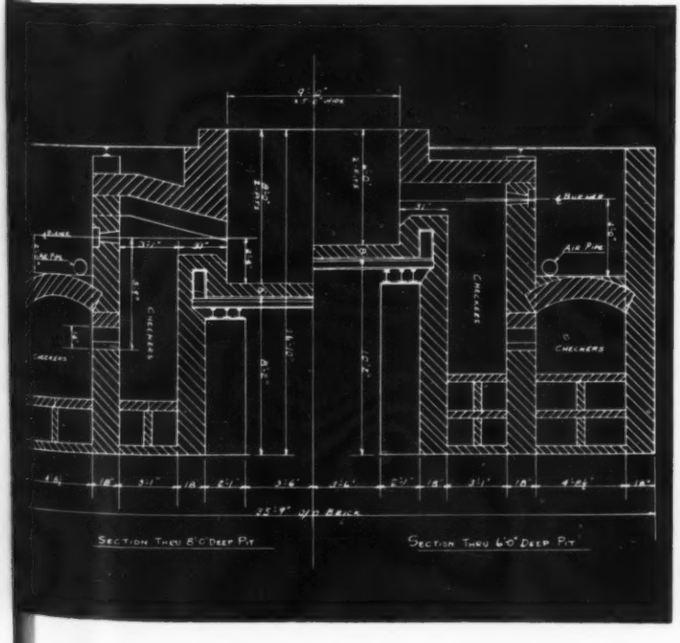
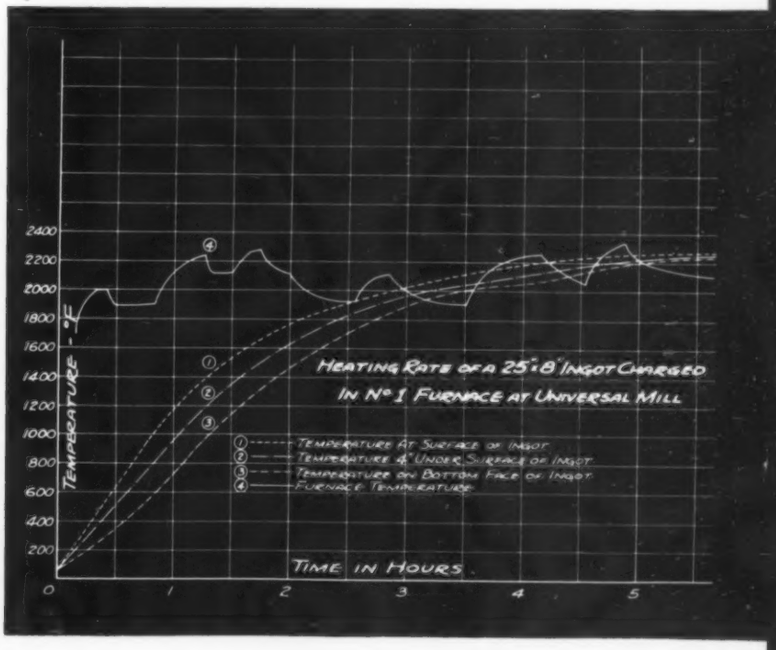


FIGURE 2—Test curve of time-temperature relation in ingot heated in side-door batch type furnace.



use, can be heated in two hours—or some such arbitrary period. Heating cycles must be based on the ability of the ingot to absorb heat safely, without injury to the original protective scale, and with assurance of uniformity and complete soaking throughout the full cross section. This is another way of saying that the greatest benefits from modern implements, with their precise mechanization and features of automatic control, accrue to those organizations which prepare selective cycles and special adaptions to cover a range of conditions or a variety of products."

There is also submitted a tabulation of heating time with coke oven gas and blast furnace gas, showing the latter fuel as requiring approximately two additional hours to heat the ingots uniformly as compared with the same type of heating with coke oven gas, for the same charging temperature.

In this connection, Figure 1 illustrates a producer gas-fired regenerative soaking pit which we recently converted to oil firing. In this particular pit we find we can easily beat our minimum heating schedule of 30 minutes per inch, but we use the time so gained for additional soaking or holding time, with the result that the ingots heated in this pit are more plastic and easier rolling.

Figure 2 shows a heating curve made on ingots treated in a batch type side door furnace in the same mill which illustrates clearly the necessity for good circulation of gases around the ingot being heated. This particular ingot was heated flat on the furnace hearth and as the heat is applied over the top of the charged ingots, the center of the ingot reaches temperature ahead of the bottom side of the ingot in contact with the hearth, this because of lack of circulation of gases between the ingot and the hearth. For this type of heating, our usual practice is to lean the first ingot charged against the backwall of the furnace giving us a saw tooth charge and allow the gases to circulate around the stock, enabling us to obtain even heating conditions and a better chance to hold to our minimum heating rate standard.

Another practice we have followed with success, is that of limiting the peak temperature of the heated ingot in case it has been determined that the ingot cannot be rolled on schedule when ready. Our practice on controlled furnaces is to limit the peak temperature to between 2100 degrees F. and 2200 degrees F. if the steel has to be held for any appreciable time, and, in case of mill breakdown that will cause a delay of several hours, the steel is held below 2000 degrees F.

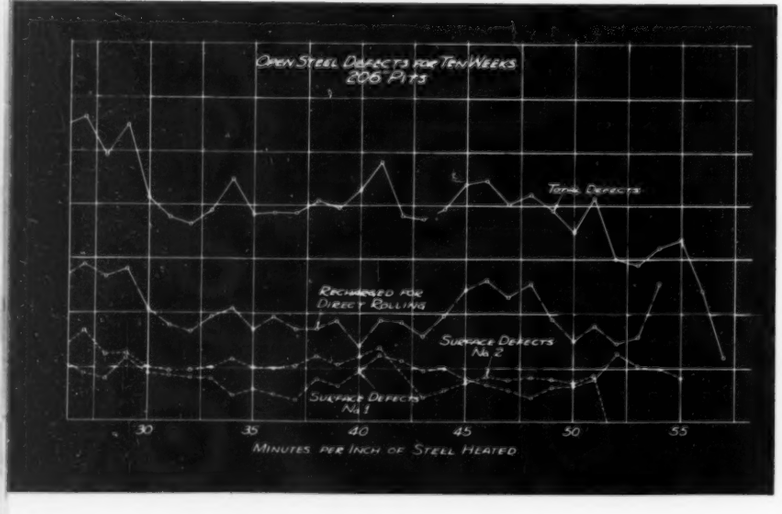
The reason for doing this is not entirely the practice of fuel economy, but rather to prevent the formation of excessive scale which cannot be prevented when the steel is held for a long period of time at the higher temperatures. D. W. Murphy in his paper presented at the Annual Convention of this Association in 1932 pointed out that the metal losses alone due to scaling in the steel industry were in excess of $1,000,000 annually.

The losses due to surface imperfections and their removal could not be covered in ten times this amount. This together with the refractory breakdown and wastage due to excessive scale accumulations in the furnaces can easily cost the industry $20,000,000 so that the doubtful saving of a surface defect which may be elimi-eliminated by a wash heat is easily dissipated in other directions.

Therefore, ingot heating calls for the same comparative care in furnace atmosphere control as billet or slab heating, if scale control is a factor. This care is best exercised by the installation of some form of fuel air ratio control, plus the use of a fuel as low in sulphur as the economics of the plant will permit, as the presence of as low as 0.1 per cent of sulphur dioxide in the products of combustion, seriously increases scaling losses at the rolling temperature, and larger amounts increase the losses still more.

Figure 3 shows a curve of surface defects plotted against heating time in minutes. This is a tabulation of results obtained on several hundred ingots showing the trend of preventable defects falling for increased heating time up to 35 minutes, when the curve begins to straighten out.

FIGURE 3—Graphical record of surface defects of steel plotted against heating time in minutes per inch of thickness.



Summing up in a few simple rules, our present procedure for heating cold ingots is as follows:

1. A heating rate of approximately 30 minutes per one inch of ingot thickness which allows sufficient time for the center of the ingot to reach the surface temperature of the ingot.
2. As close control of furnace atmosphere as present equipment will permit, to prevent excessive scaling.
3. Holding the ingot below rolling temperature when drawing schedules are upset due to mill delays.
4. The use of fuel having a low sulphur content.

The benefits derived from such practice are, lower metallic heating loss, lower surface defects due to preventable heating defects being eliminated, and better physicals in the finished product due to minimizing internal stresses by correct heat treatment before rolling and delivering the ingot to the rolls with the correct degree of plasticity throughout.

HEATING RATES for PROCESSING ALLOY STEELS,

by S. F. MAGIS

Steel Works Metallurgist
HENRY DISSTON & SONS, INC.
PHILADELPHIA PENNA.

▲ THE study of the rate of heating steel has been neglected to some extent, because for many purposes it is not considered as important in the heat treating cycle as the maximum temperature, time at this temperature and the rate of cooling. For this reason, the metallurgist has accumulated more information on these latter three factors than on the rate of heating.

Improper rate of heating may cause cracking, distortion, excessive decarburization or variation in microstructure and carburized case. The cause and prevention of any one of these troubles is a study in itself and they can only be treated as specific cases in this paper.

To determine the proper rate of heating, knowledge of the many complex variables involved is required. The variables that control the rate of heat transmission through the steel can only be considered qualitatively due to lack of adequate data on the subject.

EFFECT OF COMPOSITION

The difference in the rate of heating steels of various structural and chemical compositions may be determined by their thermal diffusivity and ductility.

The rate at which heat is transmitted through the steel is governed by thermal diffusivity which is derived from the basic Fourier equation: "Under given conditions the time required for temperature equalization inside the stock is inversely proportional to this factor". This factor is equal to the ratio of thermal conductivity to heat capacity per unit volume of steel. Heat capacity is the product of specific heat and density. Changes in composition do not effect heat capacity greatly while thermal conductivity is appreciably reduced by carbon and alloying elements.

In general the high alloy steels have lower thermal conductivities than low alloy steels. For low alloy steels the thermal conductivities decrease with increase in temperature, while for high alloy steels they increase with increase in temperature.

Ductility, which is the ability of steel to withstand a large amount of deformation without rupture, plays an important part in heating and is dependent on both composition and stresses in steel.

HEATING IN PRACTICE

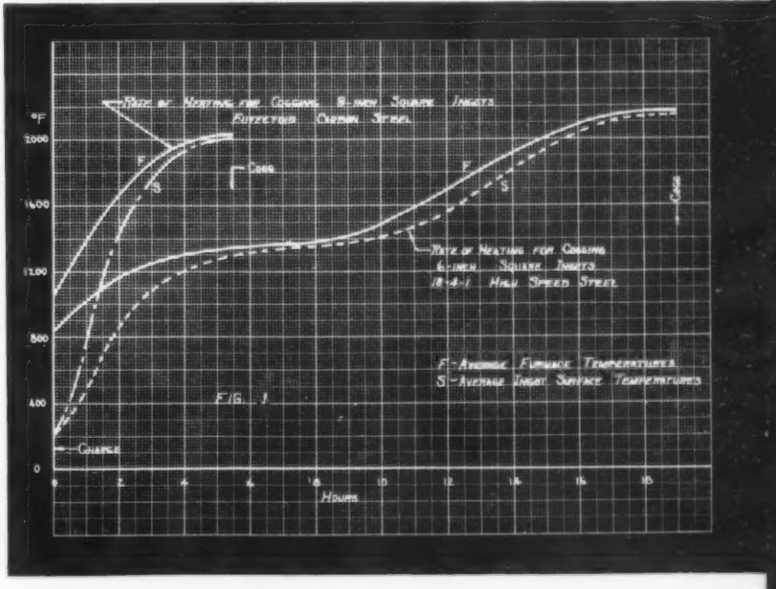
Too rapid a rate of heating, causing sudden expansion of the outer layers which may stretch the relatively cold portion in the interior of large sections of steels with low ductility, generally results in cracking. This example is a good illustration of what may happen in the early stages of heating alloy steel ingots which are generally slowly cooled to 200 degrees F. or lower following the stripping operation before heating for cogging.

The ductility of an ingot is poor because of its as-cast structure (which is composed of coarse crystals) and the high stresses present, due to the taper and design of mold. This condition is even more severe on the higher alloy steels where the as-cast structure may also contain very prominent columnar crystals. The highest ingot stresses are set up on air-hardening steels where expansion due to martensitic transformation occurs even on slow cooling. These structures yield very little to heat stresses.

Should the heating begin at too high a temperature on this type of structure, sudden expansion would crack the ingot due to the additional thermal stresses. Both diffusivity and ductility generally decreased with increase in alloy content. When heating is started at too high a temperature with low diffusivity the stresses may reach high proportions due to thermal expansion which occurs only in the outer layers since the rate of heat transmission into the steel is slow in this case. In this process the ductility is further reduced by the additional stresses. It is evident from this that high alloy ingots must be heated more slowly and longer than those of low alloy as illustrated in Figure 1.

On high speed steel ingots the rate of heating up to about 1200 degrees F. for stress-relieving takes place slowly. Following stress-relieving the heating to about

FIGURE 1—Time-temperature curves in the heating of various sizes and types of steel.



1380 degrees F. must be slow enough for the transformation from the hard to the soft constituent to take place for improving ductility. With the steel in this condition it will yield more readily to heat stresses so that the heating to cogging temperature may proceed at a more rapid rate. On the other hand, for cold ingots of higher ductility and diffusivity (such as eutectoid carbon steel) the preheating is not necessary and the heating for cogging may successfully be carried out at a more rapid rate than on high speed steel.

Annealing improves ductility and relieves stresses. High speed steel ingots in an annealed condition may be preheated at a more rapid rate. The preheating cycle may be eliminated by charging the ingots into the heating furnace immediately following the stripping operation. Ingot surface is generally about 1300 degrees F. right after stripping. In this practice the ingots are charged into the part of the furnace which is at this temperature. The stripping and charging operation must be rapid enough to avoid cooling of the ingot surface through the martensitic transformation which is accompanied by expansion. With this method an ingot charged for heating whose surface has cooled through this transformation will rupture, because of the severe stresses set up between the interior, which is still contracting, and, both the martensitic and thermal expansion in the outer layers.

The refinement of the as-cast structure by hot working improves ductility. The customary annealing operation on alloy steels preceding the hardening further improves this property. In this condition the steel can accommodate itself more readily to heat stresses so that uniform heating for hardening can proceed at a comparatively rapid rate governed by size, shape and composition.

In practice it is difficult to heat too rapidly without causing temperature variation in the stock. A steel may be ductile enough to prevent cracking in heating and still be susceptible to warping or distortion as a result of temperature non-uniformity. Obviously in heating intricate sections or plates for hardening care must be taken to avoid these troubles. Improper heating in either case not only produces changes in shape but also the temperature variations set up stresses during quenching which generally cause cracking.

Stresses and changes in shape are produced as a result of uneven expansion or where marked expansion and contraction occurs simultaneously in the steel. When cold steel is heated too rapidly in the early stages of heating, uneven expansion is produced. To avoid this condition the heating to about 1000 degrees F. takes place gradually for temperature equalization in the stock. With this preliminary preheating further danger of uneven expansion is reduced so that the heating may proceed at a more rapid rate, governed by size and diffusivity.

During the alpha-gamma transformation the specific heat reaches a high value causing the diffusivity to drop materially. Also during this period contraction of the steel takes place. If variation in temperature occurs during the transformation it may cause distortion as a result of stresses set up between parts that are expanding and those that are contracting. Distortion due to variation in heating through this transformation may be quite pronounced on large plates of alloy steels. Either by decreasing the heating rate when the temperature of the steel is about 100 degrees F. below the lower critical, or by preheating; temperature variations and excessive time during the transformation are avoided and the soaking period at hardening temperature is held to a minimum, reducing the possibilities for grain growth.

In the heating for pack carburizing or batch annealing the diffusivity of steel is relatively unimportant. Heat

FIGURE 2—Time-temperature relations in batch annealing operation.

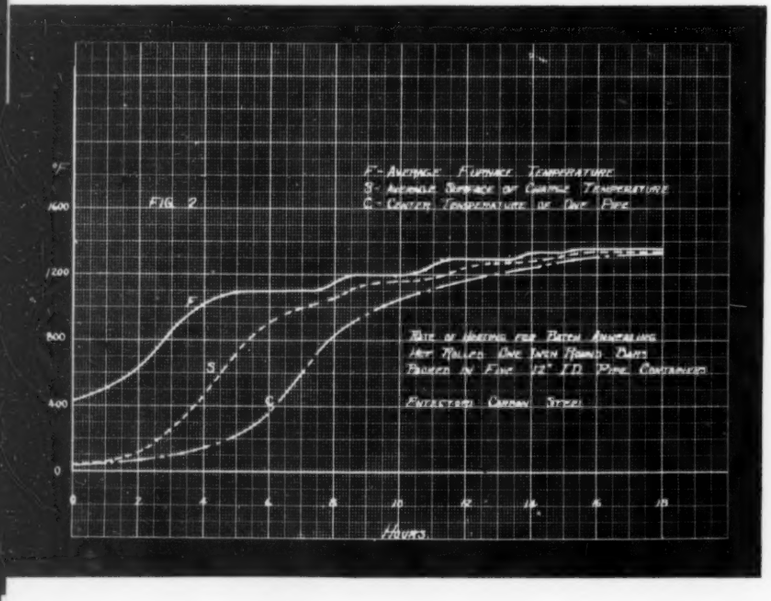
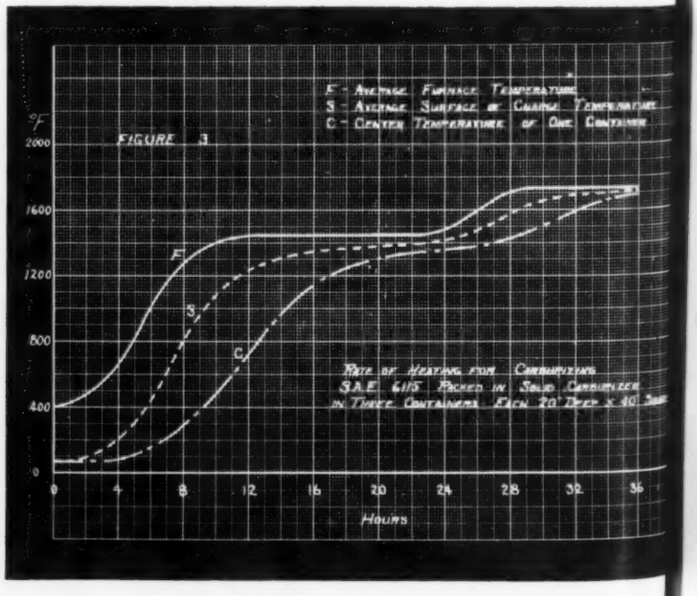

°F
FIG. 2
F - Average Furnace Temperature
S - Average Surface or Charge Temperature
C - Center Temperature of One Pipe
Rate of Heating for Batch Annealing
Hot Rolled One Inch Round Bars
Packed in Five 12" I.D. Pipe Containers
Eutectoid Carbon Steel
Hours

FIGURE 3—Time-temperature curves from a carburizing operation.


°F
F - Average Furnace Temperature
S - Average Surface or Charge Temperature
C - Center Temperature of One Container
FIGURE 3
Rate of Heating for Carburizing
S.A.E. 6115 Packed in Solid Carburizer
Hours

transfer through the material in the case of batch annealing is chiefly by radiation between the pieces. On pack carburizing the heat transmission into the charge depends largely on thermal properties of the carburizing material.

Too rapid a rate of heating on large batch annealing just below the transformation range, may cause the outer portions of the charge to "drift" above the critical resulting in a variation in microstructure. To overcome this, the furnace is set at a maximum temperature below where any important changes in microstructure take place. When the temperature is equalized in the charge the furnace is stepped up to the annealing temperature as illustrated in Figure 2. In this manner the rate of heating is gradual enough and the "drift" is eliminated.

Too rapid a rate of heating on large scale pack carburizing operations results in variation in carburized case, due to the outside of the charge being at temperature for a much longer time than the interior. Below the transformation the absorptive power of steel for carbon is very low where as above the transformation where the steel is austenitic its affinity for carbon is high. Also time and temperature in the austenitic range govern the rate of carburizing. Obviously for these reasons the inequalities in carburized case can be avoided by preheating just below the transformation of the steel as illustrated in Figure 3. By this method a minimum temperature variation is obtained and the steel will be austenitic from the outside to the center of the charge in a much shorter time.

Too slow a rate of heating in some cases may build up an excessive amount of decarburization in the steel surface. Decarburization generally begins about 1250 degrees F. on high carbon steels. Preheating below this temperature followed by rapid heating to the maximum temperature is one method by which decarburization can be held to a minimum. This method has its advantages in heating hyper-eutectoid carbon steel billets, in a slightly oxidizing atmosphere, for hot working. With preheating below 1250 degrees F. the ductility of the refined structure is further improved so that the rate of heating may be as rapid as desired, without rupture. Diffusivity of ferrite which prevails below the transformation is higher than for austenite which exists above the transformation. With this preheating, wide differences of temperature between surface and center in heating the billet from 1250 degrees F. to the hot working temperature are avoided, reducing the soaking time and in this way avoiding excessive grain size and decarburization.

On thin material such as sheets and strip, the influence of diffusivity can be neglected for all practical purposes. In this case the rate of heating will depend on the transmission of heat to the surface and it may also be governed by the initial microstructure of the steel.

For example, too slow a rate of heating in annealing hyper-eutectoid carbon strip steel for cold rolling may develop large carbides, which are difficult to dissolve in the subsequent heating for hardening, without excessive decarburization and grain growth. In this case, to obtain spheroidized carbides of proper size, requires accurate control of heating rate which is governed to a great extent by the initial microstructure. A hardened structure will spheroidize more readily and in a shorter time than lamellar pearlite with free cementite network. This latter structure requires a full annealing treatment for spheroidization. Such a practice develops too coarse a structure for the purpose intended, with more than the allowable amount of decarburization. On the other hand, a structure which will spheroidize in a shorter time presents opportunities for excessive agglomeration of carbides if heated too long. Under accurate control of heating rate, proper spheroidization can be obtained without large spheroids on the hardened structure, with less decarburization and smaller grain size.

In the foregoing, some of the problems that are met in practice have been cited, which illustrate the necessity for a definite rate of heating for each set of conditions. The methods by which the desired rate of heating is obtained for alloy steels is derived from experience by trial or by laboratory development. It is still difficult in many cases to apply laboratory heating data to commercial scale production. This is probably due to the meager knowledge of the functions of the variables involved, which cannot be dissociated.

HEATING FOR FORGINGS

By T. A. LEWIS, Combustion Engineer
BETHLEHEM STEEL CO.
BETHLEHEM, PENNA.

▲ PRESENT day ferrous forging practice covers a wide range of steel quality and shapes within the size range of stock of less than 1 inch diameter to ingots of over 100 inches diameter. The forgings produced are, in general, within the weight range of less than a pound up to several hundred thousand pounds.

The heating phase, therefore, is concerned with the requirements called for in the above field. Considered from a metallurgical standpoint, the requirements most stressed are those of heating rates, proper forging temperatures and furnace atmosphere conditions.

I. Heating rates and temperatures

Heating rates and temperatures are pretty well established from a heat transmission standpoint. The scope of this paper does not permit considering the individual heating requirements of each of the many grades of forging products. They are here considered as falling within general groups in which the following rules are customarily applied:—

(1) For plain carbon steel of 0.5 per cent carbon or less, a minimum time of 5 min. per 1 inch diameter or thickness in sizes up to 3 inches is considered permissible although some metallurgists prefer a slower rate of heating. For steels having higher than 0.5 per cent carbon, slower rates are employed.

In general, bars having 1 per cent carbon and over 1 inch diameter, should be preheated before placing in the forging furnace. In carbon steels, forging tempera-

tures run to 2400 degrees F. for very low carbon, and down to 1900 degrees F. for very high carbon.

(2) Alloy bars and billets with up to 0.6 per cent carbon, which have certain alloy properties, may be heated at the rate of 6 minutes per 1 inch diameter up to 3 inches diameter. With higher carbon percentages and larger sizes, the heating rates are proportionately slower. Forging temperatures usually run from 2350 degrees F., with low carbon content steel, down to 2200 degrees F. for higher carbon grades.

(3) In high speed billet heating it is customary to follow the rule of 1 inch per hour, or the number of hours required is the same as the thickness of the billet in inches. Slow initial heating is required with a minimum of heating time at the higher heating range. Forging temperature is about 2150 degrees F. Uniformity of heating and furnace atmosphere conditions are stressed in this heating process.

(4) High speed ingot heating is generally stressed from the standpoint of providing a maximum time for preheating up to about 1600-1650 degrees F. From this point, up to the forging temperature of about 2150 degrees F., the heating time allowed is generally approximately half that consumed during preheating. The same considerations of careful heating are applied here as in (3) above. A typical heating schedule would be about as shown below:—

Ingot size inches sq.	Pre-heating time hrs.	High heat hrs.	Reheating high heat, hrs.*	Total hrs.	Billet size in. sq.
7½	24	12	2	38	4x4
9	28	16	4	48	4½x4½
12	38	20	6	64	6x6
13	42	22	8	72	8x8

*Represents time between forging operations.

(5) In heating large ingots for forging, when charged at an ingot temperature of around 1000 degrees F., the heating rates are comparatively high. These rates may run from 5 inches per hour in the smaller ingot to 2 inches per hour in the very large sizes. These rates are for low to medium carbon steels as well as for many alloy grades. An example of such a heating schedule follows:—

Ingot size (inches)	20	24	30	36	42	48	54	69	92	108
Time in mould —hrs.	2	2	3	4½	6½	9	11	20	38	52
Time heating (hrs.)	4	5	6	8	10	12	18	32	44	54

(NOTE—Initial ingot temperatures—1000 degrees F.)

In heating ingots from a cold state, heating practice usually follows the rule of 1 inch per hour in the larger sizes with shorter times allowed in the smaller sizes, due allowance being given for alloy properties.

(6) In actual practice, the exact time in heating for a given forging is influenced by various working conditions. In small drop forge work, in furnaces where very good temperature uniformity is maintained, the heating rate may become a function of the heating capacity of the furnace.

In large ingot heating furnaces, such factors as flame temperature, flame radiation, brick radiating surface and degree of temperature uniformity throughout the furnace will influence the length of time a forging must be heated to reach the temperature condition required for proper working. The position of the ingot within the furnace with respect to its ability to uniformly absorb heat is another influencing factor. These and other conditions, which influence the rate of heat transfer from the furnace to the material being heated vary considerably in different instances and are among the contributing reasons why heating times are not entirely standardized in general practice.

II. Fuel rates in heating for forgings.

For purposes of comparison, the fuel used or the heat input to a furnace per unit weight of steel heated may be stated in terms of Btu. input per gross ton steel produced. These rates in forging heating vary a good deal depending upon the type of work and upon the furnace and combustion equipment used. The extent to which the furnace capacity is utilized in many forging processes is found to vary greatly in actual forge practice.

Assuming, perhaps, somewhere near average conditions, the following will indicate fuel rates in some typical forging processes:—

(1) Hammer forge work in billet sizes of 1 inch to 6 inches diameter. Fuel rate—5,000,000 Btu. ton produced.

(2) Tool steel ingot heating for cogging (Ingot sizes 9″ x 9″ to 12″ x 12″). Fuel rate—20,000,000 Btu. ton produced.

(3) Ingot heating for large press work (Ingot size 108 inches dia.) Charged at 1000 degrees F.

(a) Heating to temperature for first forging. Fuel rate—3,000,000 Btu. ton produced.

(b) Heating to temperature for each succeeding forging operation. Fuel rate—600,000 Btu. ton produced.

(c) Heating for total finished forging based on ten heats required. Fuel rate (total)—9,000,000 Btu. ton produced.

The above fuel rates for forging processes can be considerably reduced in individual furnaces, where all factors influencing the heating rates can be made ideal. Similarly, in forge shops, where the type of forgings is standardized within a narrow range, the effect will be in the direction of lower fuel rates.

III. Furnace atmosphere and forging surface conditions.

The subject of furnace atmosphere in forging practice is one which deserves a continual study. Although the factors of time and temperature are recognized as being of the most importance in affecting the surface of material heated in the forging range, furnace atmosphere is a contributing factor. The proper atmosphere for a given steel can be ascertained only by experimentation. There remains much to be learned

about this subject, and there are apparently many factors and combinations of conditions whose workings are not always predictable. That this is true, is indicated by varying results obtained in individual setups, when the known conditions in each case appear to be nearly identical. Similarly, when tests are run in the field, using different fuels and different combinations of atmospheres, it is often difficult to correlate definite atmospheres with definite steel surface results.

Perhaps the outstanding reason why there is so little actually known about the relationship of atmosphere with scaling and other surface conditions, is that too many possible contributing factors have been unknown or taken for granted. With the more widespread use of furnace and combustion control equipment, and a closer tie-in between the metallurgical, operating and combustion phases of the problem, a more rapid advancement in knowledge of the subject will undoubtedly take place in the future than has been made in the past.

At the present time, a reducing atmosphere appears to be rather generally accepted as being the most desired for most forging heating. In the case of special alloy steels, a highly reducing atmosphere is usually favored, while in simple steels, a neutral or slightly reducing atmosphere condition is often maintained.

To the contrary, there has been excellent heating results on tool steel by having a controlled atmosphere that is slightly oxidizing. Analyses of 1 per cent oxygen build a slight scale on the steel heated that tends to prevent further surface destruction.

Unfortunately, scale losses and other detrimental surface conditions are usually most excessive in the special steels, where scale losses alone may be as high as 8 percent of the total weight of the material.

IV. Furnaces and furnace equipment.

In forging practice, the problem of furnace design and the application of proper heating control equipment is of vital concern. This is true in all classes of forging work and especially in the case of the special heating required in various alloy grades. Particularly in the latter case the value of the product heated will alone justify the utmost attention to this problem.

An example of some of the requirements necessary in a furnace used for heating special alloy ingots and billets for forging would include the following:—

(1) Furnace must be large anough for maximum production needs, but not too large for the lowest rate of firing from the standpoint of flame temperature uniformity and ability to maintain a proper furnace pressure and atmosphere condition throughout the heating range.

(2) Burners, fuel-air ratio control, furnace damper control and other heat controlling equipment must fit into the conditions expressed in (1) above.

The heating requirements noted above are especially difficult, chiefly because of the varied rates of firing, which have to be met and controlled.

In most other forging heating, fuel input is generally rather constant although the factors of temperature both as to degree and uniformity throughout the furnace are always of major importance.

The question of utilizing furnace capacity is one which the writer believes does not usually receive the attention it warrants. There are many examples where a forging furnace is designed for a given maximum size of work and at some later date the demand changes to a much smaller size. In many such cases, if the heating remains satisfactory from a forging standpoint, the furnace will continue to be used. Whether or not such a furnace should be redesigned to a suitable size or replaced, is, of course, dependent upon ultimate considerations of savings. That these considerations should be made, however, is apparent since fuel cost in forge shop practice is a major one even when low priced fuels are consumed.

DISCUSSION

OF

HEATING RATES OF STRIP STEEL AND TIN PLATE PRODUCTS

L. F. COFFIN: I have a question, Mr. Fisher. You show the heat release greater in the oil fired furnace. What will happen in the case of slab heating if your change to 500 Btu. coke oven gas-firing?

A. J. FISHER: The heating rates will not be as fast, the pounds of steel per square foot per hour will be less.

L. F. COFFIN: That is going to reduce the capacity of a furnace?

A. J. FISHER: That is right. There is another furnace function involved and that is the capacity of the stack and the pressure drop through the recuperator or regenerators and the flues which would enable you under the same conditions to burn more oil than gas in the same furnace. However if there is an excess capacity for oil-firing, the furnace volumes for gas-firing may be all right. Of course the gas-fired furnace can be designed to do the same job as the oil-fired furnace.

L. F. COFFIN: The same size furnace?

A. J. FISHER: No, a different size furnace.

L. F. COFFIN: Will you explain the difference between slab heating for strip and for sheets there—between heating the hot strip and heating the sheets, where you have 70 pounds per square foot per hour for the strip and 30 pounds per square foot per hour for the sheet.

A. J. FISHER: The reason for that difference is: in column one the thickness of the slab is 4½ inches in the one case, and 2 inches in the other case with the

same temperature. In the first case the slabs are flat, and one high. In the second case the piles are flat and the slabs are piled one on top of the other, making it a rather bulky mass of material to heat through.

L. F. COFFIN: How many are in the piles of slabs?

A. J. FISHER: Well there may be as many as six or seven, but the width there is 12 inches; so in reality, you would have a minimum heating thickness of 12 inches, if you took the piles and slabs as a unit.

L. F. COFFIN: In the box annealing on tin plate, the heat release per square foot of hearth area is higher for the oil than the gas, does that mean the furnace is less efficient on the oil than gas, or are the two operations comparable?

A. J. FISHER: The two operations are not comparable. One operation has the conventional in and out oil-fired furnaces, whereas the other has the radiant tube gas-fired furnaces.

M. J. CONWAY: I have nothing to offer on Mr. Fisher's paper, outside of the fact that I would like to know if he was using luminous flame burners on the furnaces that were gas-fired?

A. J. FISHER: The only luminous gas-fired furnaces are the two sheet normalizing furnaces. One employs the use of luminous flame burners whereas the other has non luminous flame burners but has installed in the soak zone an oil burner for making the desired luminosity.

DISCUSSION
OF
SOAKING PIT HEATING RATES FOR COLD INGOTS

W. PAUL GERHART: I have a question to ask. Do the heating rates mentioned by you apply when ingots charged at 1500 degrees F. are heated to 2300 degrees F.?

M. J. CONWAY: No, Mr. Gerhart, they do not. They only apply to ingots which are charged in the pit or furnace cold.

G. B. MCMEANS: I would like to ask Mr. Conway about the uniformity of temperature from front to back of pit. In pulling a pit for the mill, do you expect to obtain any better uniformity of your finishing temperature by pulling the front half of number one pit, then going over and pulling the front half of number two pit, after which you return to complete the withdrawal from number one pit and number two in turn? Will damper control aid in attaining the uniformity desired, for steel in all locations in the pit, so that the entire charge may be withdrawn consecutively?

M. J. CONWAY: I see no reason why all of the ingots cannot be drawn from a single pit before moving on to the next pit if the pit has been brought up to temperature correctly. There is no doubt, Mr. McMeans, that damper control, or rather, furnace pressure control, is a great aid to uniformity in the heating of product in any furnace, and should certainly aid you to draw the entire charge consecutively, providing you do not charge cold steel adjacent the hot steel before the pit is empty.

A. J. FISHER: I would like to know whether or not you vary the reversing time of the soaking pits in relation to the time that the heat or the ingot is to be drawn.

M. J. CONWAY: I can best answer your question by telling you that we have both recuperative and regenerative pits, and the same amount of time is required to give us the required heating at both pits, so that independent of balancing the furnace itself, there is no reason for varying our reversing time on the pits. Bear in mind I am referring to cold steel charging practice only, but I see no reason to vary on other practice.

A. J. FISHER: What is the time of reversal?

M. J. CONWAY: Around fifteen minutes.

M. J. BRADLEY: I should like to ask Mr. Conway how the temperatures of the ingot surfaces were measured. Does the surface temperature curve shown represent the average temperature condition within the pit, or in other words the heat head surrounding the ingot, or is it actually the ingot surface temperature? If the latter, how were the measurements made?

M. J. CONWAY: I believe I referred to the fact in my paper that we first took ingots of various thicknesses and drilled into them at various depths from the surface to the center, and after attaching thermocouples to the points which were drilled, determined by test how long it took for the center of these ingots of various thickness to come up to rolling temperature. After having made these determinations and from them plotted curves, we arrived at an arbitrary time for heating these ingots of various thickness. Do you mean the checking of the average ingot as we draw it? Not the test ingots?

M. J. BRADLEY: No, what I wish to find out is the method or thermocouple used in measuring the temperatures shown on the slide for the surface curve.

M. J. CONWAY: The surface temperature of the ingot was taken by attached thermocouples on the test ingots and checked with an optical pyrometer sighted on the ingot in the pit with the fuel turned off.

M. J. BRADLEY: Then it does not represent the "head" or the equilibrium temperature among the pit walls, flame, and ingots.

M. J. CONWAY: That was the actual temperature of the steel ingot as determined by an optical and attached thermocouple to a recording pyrometer.

DISCUSSION OF HEATING RATES FOR PROCESSING ALLOY STEELS

M. J. CONWAY: I have a question to ask Mr. Magis. What is the average size of the alloy ingots referred to by the curve, and what are the temperatures?

S. F. MAGIS: The heating curve for high speed steel is on 6 inch square ingots and the hot working temperature is about 2150 degrees F. for this composition. The curve for eutectoid carbon steel is on 9 inch square ingots and the hot working temperature is about 2000 degrees F. for this grade.

A. J. FISHER: Mr. Magis ended up by saying that there is a little trial and error possible in determining these curves. I would like to have him tell us how to go about setting up the temperature curve for a new type of steel.

S. F. MAGIS: The method of heating for some purposes can only be derived from experience by trial. Proper heating curves for small sections of steel, which are individually heated, may be successfully determined in the laboratory. On the other hand, curves for batch heating can only be developed in actual practice. In this case the method of heating is refined from heat to heat until the desired metallurgical results are obtained. The reason for employing this method, is no doubt due to the difficulty in duplicating in the laboratory the many variables met in practice.

In developing a heating practice for a new steel it is expedient at the inception, to pattern it from an established heating cycle of a steel, whose properties are similar under comparable furnace conditions.

DISCUSSION OF HEATING FOR FORGING

LOUIS MOSES: The subject is a vital one affecting the quality of the material being heated with the costs of first rank importance. The papers show all the earmarks of painstaking preparation and form a decided and welcome contribution.

Listening to Mr. Fisher I note his way of comparing the weight of the heated steel with the area of the furnace hearth. Mr. Conway lists rates of heating by time interval versus cross-section. Mr. Magis and Mr. Lewis use time consumed per unit depth of penetration.

The electrical fellows who are so well represented here denote a lot of information by the use of the symbol kva.

As a thought coming from a mere mill-man, cannot you combustion fellows similarly find a common denominator which indicates the efficiencies of fuels, rate of heat transfer, etc.?

A. J. FISHER: I would like to ask Mr. Lewis what type of gas flame he would consider best for all types of forgings; whether the gas used should be a low Btu. or a high Btu., or whether it should be luminous or non-luminous?

T. A. LEWIS: The fuel used is dependent upon plant economic problems. Our plant, like most steel plants, has large quantities of by-product fuels, namely, tar, coke oven and blast furnace gas. Our purpose is to utilize the by-product fuels to the fullest extent so that little additional fuel is purchased. The fuel balance of the plant greatly influences the kind of fuel to be used. Any of the by-product fuels will heat forgings satisfactorily providing your equipment and furnace is properly designed.

We have found in practice that low calorific fuels such as blast furnace gas is very desirable for large forgings, while high calorific fuels such as coke oven gas, or liquid fuel, is more adaptable to drop forgings or small forgings that are heated to relatively high temperatures in fast time. The heating of large forgings tends to be more uniform with a low calorific fuel as the lower flame temperature is dissipated around the greater part of the forging, while the higher flame temperature of the richer fuels tends to radiate its heat to smaller sections of the forging.

Heat transfer to forgings is more rapid with a luminous flame than a non-luminous flame. However, there are compensating values in heating large forgings with the non-luminous and lower flame temperature fuels. Forging temperatures above 1800 degrees F. require preheating in blast furnace gas application. On small forgings, there is an advantage with the luminous flame.

L. F. COFFIN: I would like to ask Mr. Lewis to give us the same general comments applying to 12" square forgings heated with luminous gas flame.

T. A. LEWIS: The same story applies there with the exception that the tonnage is on the low side of the smaller forgings. If the amount of steel is not high in tonnage, I would be apt to go on the higher calorific fuels, because there are less complications. But if the heat balance requires it, I'd go the other way.

American Cast Iron Pipe Company

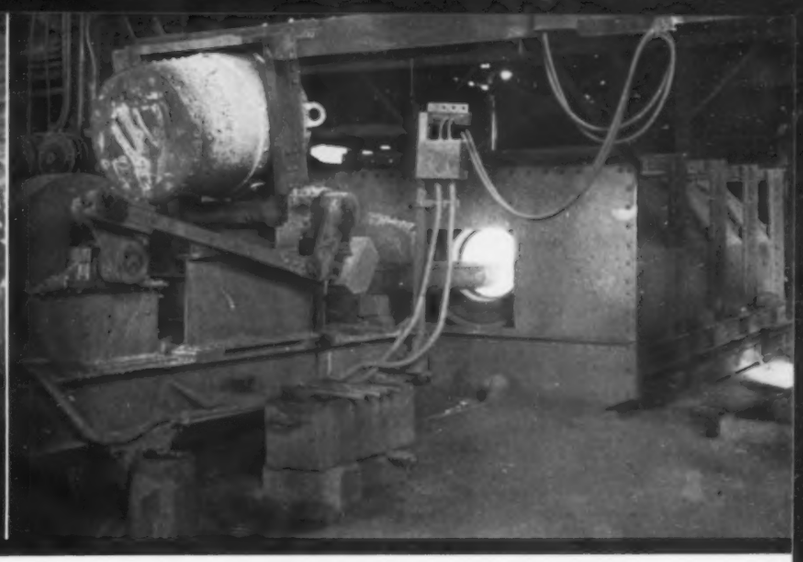
▲ ON Monday, March 27, the Association of Iron and Steel Engineers will sponsor an inspection trip to the American Cast Iron Pipe Company at Birmingham, Alabama, the largest individual cast iron pipe foundry in America. From a small beginning in 1905, this organization has taken a position in the front rank of American industry, producing a complete line of cast iron pressure pipe and fittings.

Upon arrival at the plant, pig iron is analyzed for silicon, sulphur, manganese and phosphorus, before being unloaded into classified storage bins on the iron yard. Coke and limestone are likewise carefully selected and unloaded upon arrival in the plant. These materials, so chosen as to give a product of the desired analysis, are charged into cupolas of various diameters. When melted, the iron flows continuously into a large mixing ladle, from which it is poured into bull-ladles and conveyed by mono-rail cranes to pouring ladles located at the casting machines.

Pipe casting is effected by the centrifugal process, using sand-lined refractory molds. There are two Mono-Cast centrifugal shops, one which produces pipe 3 inches to 12 inches in diameter, while the other produces 14-36 inch pipe. This process produces a very uniform pipe of strong dense structure.

After casting and stripping, the pipe is thoroughly cleaned inside and out, and subjected to a hydrostatic pressure test of 500 pounds per square inch. If intended for water service, after weighing and inspecting, it may be coated by dipping in hot tar, or, optionally, may be enamelined with cement mortar; if for gas service, it is air-tested in addition to the hydrostatic test. Cement-lined pipe may be made on the enamelining machine by increasing the thickness of the lining.

Iron of the desired composition is melted in cupolas, poured into mixing ladles and conveyed to pouring ladles located at the casting machines.



Pipe is cast by the centrifugal process, using sand-lined refractory molds. A very uniform product of strong dense structure is obtained.

Following the above procedure, the pipe is sent to the shipping yard for shipment or storage.

A special foundry produces a complete line of cast iron fittings. Completed fittings are inspected in a manner similar to that of pipe, and after inspection are stored in the yard. Products are handled in the shipping yard by locomotive cranes.

Complete testing facilities provide a means for a thorough check of the physical properties of the pipe. These tests include hydrostatic and air pressure tests, bending, impact and crushing tests, as well as chemical tests that are maintained as routine practice. A complete metallographic department is also included for making photomicrographs and structure studies of the iron.

The plant also includes a pattern shop, machine shop and electric shop as well as the necessary service and maintenance departments.

An unusual feature of this company is that all of the common stock of the company is held in trust for the employees of the company. This unique condition is the result of the benificence of the founder of the company, John J. Eagan. Upon his death in 1924, it was found that his will left all common stock of the company to the members of the Board of Management and the members of the Board of Operatives of the company, who jointly vote the stock. The Board of Management consists of the executive committee of the Board of Directors, while the Board of Operatives consists of twelve employees selected by the employees themselves. Thus, the company is truly under employee management.

An extensive program of welfare service work is carried on by the company, including medical and hospital service, sick and accident benefits, pensions, group insurance, loan fund and other helpful measures.

Educational Program-Detroit Section

By L. R. MILBURN, Chairman
DETROIT DISTRICT SECTION
A. I. & S. E.

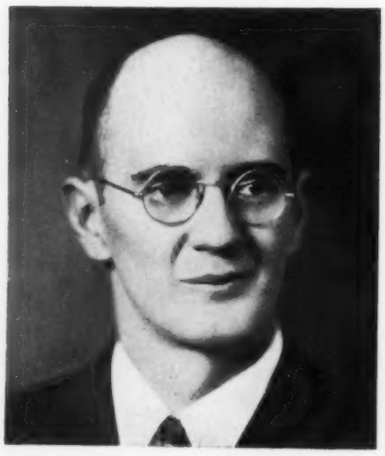
▲ THE Detroit Section of the Association of Iron and Steel Engineers received its educational allotment of one thousand dollars in October, 1938. This fund was to be used for an educational project of the section's own choice.

Accordingly, an educational committee was appointed consisting of L. M. Ripple, Clarence Altenburger, and the writer, all of Great Lakes Steel Corporation.

This committee first made a study of the educational work and methods of the other sections as well as a canvass of the section membership for ideas. A study of local conditions was also made, so as not to interfere with any schools or educational programs of industrial companies in the area, and the Deans of the local engineering schools and colleges were also contacted. With the information thus gleaned, a concrete plan of action was prepared and submitted to the Executive Committee for approval. This plan consisted of the following:

1. Since two hundred fifty dollars ($250.00) would finance a student through one year at any of the four local colleges in Detroit, the thousand dollars would be divided into four equal parts, thus granting privileges to four boys.
2. An attempt would be made to find four sons of members who wanted to go to college but could not finance themselves.
3. The plan would be limited to students who would study engineering, chemistry, or metallurgy, leading to the advancement of the steel industry.
4. The boys would take full time courses and devote all their time to study.
5. The student would be allowed to choose the college he wished to attend.
6. The student to be, at the time of applying, a graduate of an accredited high school and must be able to enter the school of his choice without conditions.
7. Applicant must be an American citizen.
8. The applicant would be classed in the following groups:
   (a) Sons or relatives of members.
   (b) Acquaintances of members.
   (c) Students recommended by local schools.

L. M. RIPPLE



L. R. MILBURN

CLARENCE ALTENBURGER

WM. VON MOLL

Wayne University

WM. J. O'BRIEN

University of Detroit

SCHOLARSHIP WINNERS A. I. & S. E. DETROIT SECTION EDUCATIONAL PROGRAM

They would be further subdivided:

(1) High school graduate at the time of making application.
(2) Having completed some college work.
(3) Taking post graduate work.

9. The applicants who could meet all the above requirements must then seek an interview with the committee for further questioning for final approval.

Notices were posted in the various steel plants of the Detroit area.

By this means twenty-nine applications were obtained, none of which were from sons or relatives of the membership.

These twenty-nine applicants were weeded out until ten remained, who received a final interview with the committee. Some could not pass the requirements of the various colleges. Others had moved out of town; and some had not graduated from high school as yet.

The committee held two meetings for these interviews and further cut these ten applicants down to six. The highest four of these were finally selected for the four scholarships, with the last two picked as alternates.

Winners of the scholarship awards are:

Wm. Von Moll, who will attend Wayne University, Wm. J. O'Brien, University of Detroit, Karl Reber, University of Detroit, and Robert L. Scholz, who selected University of Toledo.

These individuals will begin their work at the selected schools in the early part of 1939.

The Detroit Section is pleased with their solution of a difficult problem, and hopes that their project will meet with a success which will warrant the Association seeing these four men through their college careers. This type of a solution put a rather heavy burden on the Detroit group, but the successful performance of these men will justify the selection of this plan, and the Detroit Section will feel amply rewarded.

SCHOLARSHIP WINNERS A. I. & S. E. DETROIT SECTION EDUCATIONAL PROGRAM

KARL REBER

University of Detroit

ROBERT L. SCHOLZ

University of Toledo

DETROIT DISTRICT SECTION

ASSOCIATION OF IRON AND STEEL ENGINEERS

INSPECTION TRIP

•

New Coke Ovens and Blast Furnace, Great Lakes Steel Corporation. Buses will leave Fort Shelby Hotel at 1:30 P. M.

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TECHNICAL SESSION

At the technical sessions C. P. Betz will present a paper describing the design, construction, and operation of the new coke plant at the Great Lakes Steel Corporation; and R. M. Hughes, Assistant Chief Engineer, will cover the same points in his paper on the new blast furnace.

L. R. MILBURN, *Chairman*

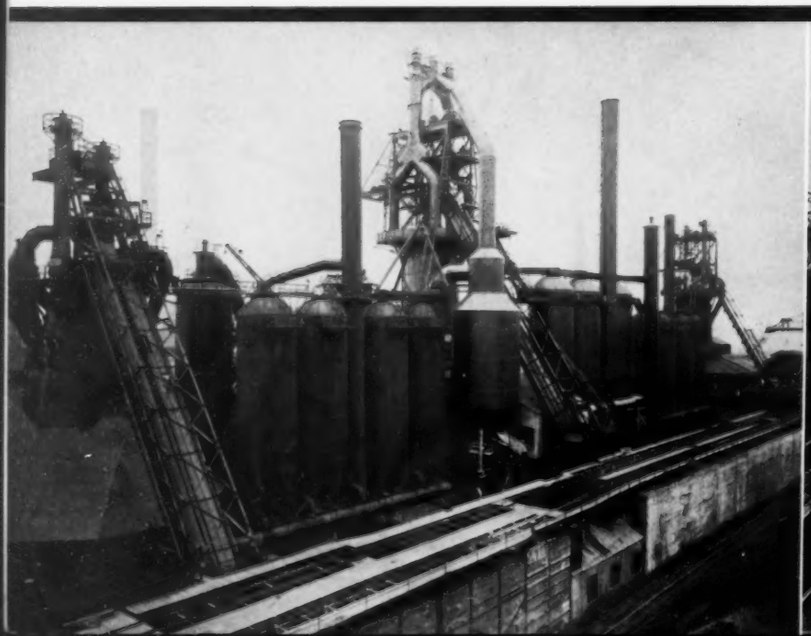
WEDNESDAY, APRIL 19, 1939

DINNER - 6:30 P. M.
MEETING - 8:00 P. M.

CRYSTAL BALLROOM - FORT SHELBY HOTEL

The inspection trip will cover the coke and blast furnace plant of Great Lakes Steel Corporation, in which many new features are incorporated.

The new coke plant is of the latest design, and includes a continuous distillation plant for light oil recovery.



OFFICIAL PROGRAM

ASSOCIATION OF IRON AND STEEL ENGINEERS

Annual Spring Conference

BIRMINGHAM, ALABAMA, MARCH 27-28, 1939

HEADQUARTERS HOTEL TUTWILER

Tennessee Coal, Iron and Railroad Company

United States Steel Corporation Subsidiary

General Offices: Birmingham, Ala.

ROBERT GREGG
PRESIDENT

January 14, 1939.

Association of Iron and Steel Engineers,
Empire Building,
Pittsburgh, Pennsylvania.

Gentlemen:

My associates in the Tennessee Coal, Iron and Railroad Company join me in welcoming you to Birmingham for your annual Spring Engineering Conference to be held here March 27-28. We are fully aware of the cooperation of the Association of Iron and Steel Engineers with the steel industry in the development of the industry's present position.

Engineering has a vital position in the steel industry, and this brings emphasis upon the importance of the industry's cooperation in engineering activities. Your technical discussions here will, I am sure, be further contribution to the advancement of steel making and steel uses.

I feel sure that you will be impressed with your visit to our hot strip mill and our tin plate mill at Fairfield, and I sincerely hope that your visit in Birmingham will be not only enjoyable but successful in every respect. We are happy to have you.

Assuring you of our interest and pleasure of cooperating, I am,

Sincerely yours,

Robert Gregg

President.

Robert Gregg

PRESIDENT

Tennessee Coal, Iron and Railroad Company

Karl Landgrebe

VICE PRESIDENT

TENNESSEE COAL, IRON AND RAILROAD COMPANY

THE inspection trip to the Tennessee Coal, Iron and Railroad Company includes visits to their entire property in the Birmingham district, from mines to finishing facilities. The trip will consume the entire day, and will be made by special train equipped with loud-speakers, so that a running description of the trip may be transmitted through the train. These facilities, as well as luncheon at the plant, are extended through the courtesy of the Tennessee Coal, Iron and Railroad Company and were arranged through the efforts of Mr. Karl Landgrebe, vice president of that company.

F. M. STURGESS

R. R. THOMAS

BIRGER THELE

CONFERENCE PARTICIPANTS

J. A. CLAUSS

WM. MANDY

H. T. WATTS

C. C. PECU

The fortunate trinity of iron ore, coal and limestone in the Birmingham district provides solid foundation for the iron and steel industry. Pictured at the top are furnaces of the Sloss-Sheffield Steel and Iron Company, which operates four furnaces in the district. Immediately above is a general view of the plant of the American Cast Iron Pipe Company. Below is an aerial view of the Gulfsteel plant of Republic Steel Corporation.

OFFICIAL PRO

Annual Spring Co

MONDAY, MARCH 27

8:45 A. M.—Registration—Main Lobby, Hotel Tutwiler.

9:00 A. M.—Technical Session, Ball Room.

Chairman:

R. R. THOMAS, Assistant Chief Engineer
Tennessee Coal, Iron and Railroad Company
Ensley, Alabama

Vice-Chairman:

C. C. PECU, Lubrication Engineer
Bethlehem Steel Company
Lackawanna, New York

"Relay Protective Methods for Steel Mill Service"—by H. A. Travers, Power System Engineer, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

"Modern Wire Drawing Practice" by J. J. Phifer, Superintendent, Fairfield Wire Works, Tennessee Coal, Iron and Railroad Company, Birmingham, Alabama.

"Lubricants Essential to the Steel Plant"—by William Mandy, Texas Company, Birmingham, Alabama.

12:30 P. M.—Luncheon.

1:45 P. M.—Inspection Trip. American Cast Iron Pipe Company, Birmingham, Alabama. Buses will depart from from Hotel Tutwiler.

6:00 P. M.—Dinner. Address of Welcome by Robert Gregg, President, Tennessee Coal, Iron and Railroad Company, Birmingham, Alabama.

PROGRAM

Conference . . . . .

8:00 P. M.—Technical Session. Ball Room.

Chairman:
H. T. WATTS, Combustion Engineer
Republic Steel Corporation
Gadsden, Alabama

Vice Chairman:
J. A. CLAUSS, Chief Engineer
Great Lakes Steel Corporation
Ecorse, Michigan

"Modern Pit Design and Practice at Fairfield Works"—by E. A. Hawk, Fuel Engineer, and M. P. Burns, Assistant Fuel Engineer, Tennessee Coal, Iron and Railroad Company, Ensley, Alabama.

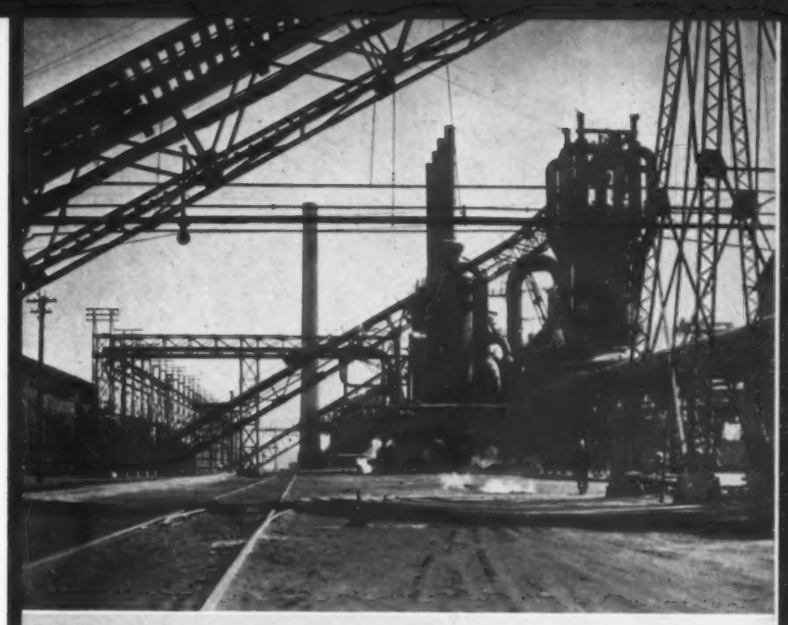
"Southern Blast Furnace Practice"—by J. E. Urquhart, General Superintendent, Woodward Iron Company, Woodward, Alabama.

TUESDAY, MARCH 28

8:30 A. M.—Inspection Trip. Tennessee Coal, Iron and Railroad Company properties. (Entire day will be devoted to this trip.)

OPTIONAL TRIPS

While there will be formal inspection trips to the American Cast Iron Pipe Company and all properties of the Tennessee Coal, Iron and Railroad Company, arrangements have been made whereby all our members and guests will be welcome to visit the other industrial plants in the Birmingham area after the conclusion of the conference. The managements of the Republic Steel Corporation plants in the Birmingham and Gadsden districts, the Woodward Iron Company, Sloss-Sheffield Steel and Iron Company, and the United States Cast Iron Pipe Company, will be very glad to show everyone through their plants. Necessary arrangements for such trips will be made by the individual members.



Expansion of the steel industry in the Birmingham district is well represented by the new tinplate project of the Tennessee Coal, Iron and Railroad Company, at Fairfield. Republic Steel Corporation also operates another plant in the district consisting of two blast furnaces located at Birmingham. Pictured below is a general view of part of the plant of Woodward Iron Company, which operates three furnaces in the district.

LUBRICANTS

ESSENTIAL TO THE STEEL PLANT

By WILLIAM MANDY
The Texas Company
Birmingham, Alabama

Abstract of paper to be presented before the A. I. & S. E. Annual Spring Conference, Birmingham, Alabama, March 27-28, 1939.

▲ THE purpose of the paper is to explain the various factors which must be taken into consideration when making lubrication recommendations for steel mill equipment. These factors are taken up individually in the order in which they appear in the following outline:

I—Location of the mill. It is important to give consideration to the geographical location of the mill with respect to its proximity to other industries which might cause contamination of lubricants, also its proximity to a source, of cooling water and how the selection of lubricants in the various mills are influenced by the variations in climatic conditions in different sections of the country.

II—Type and age of mill. Economy in proper selection of lubricants depending upon the age, type and mechanical condition of the equipment, are discussed.

III—Operating conditions are discussed in detail from several angles to show how they have a direct bearing, not only on the selection of the lubricant but also on the method of application. Types of lubricants and their method of application are recommended to overcome the ever-present problem of contamination in enclosed gear units which are not and perhaps cannot be adequately enclosed and sealed against the entrance of foreign materials. The tendency toward the use of a better class of labor in steel mills for the actual lubrication of the equipment is rapidly increasing as the importance of lubrication is being recognized and as more modern mills are being installed.

IV—Familiarity with various lubricants. Outlines the duties of the lubrication engineer in the steel mill and suggests frequent discussions on lubrication matters between himself and the maintenance men to help reduce the number of lubricants required in the mill. Reasons are offered for the use of lubricants under brand names and how this affects the number of lubricants used.

V—Description and uses of lubricants. Gives a brief description, the methods of application and general uses of the following lubricants which are usually found in steel mills:

1. Black oils
2. Journal oils
3. Red engine oils
4. Pale oils
5. Turbine oils
6. Steam cylinder oils
7. Cup greases
8. Low melting point pressure gun greases
9. High melting point pressure gun greases
10. Extreme pressure greases
11. Extreme pressure gear lubricants
12. Residuum gear compounds
13. Hard tallow or cold neck greases
14. Hot neck greases

Some of the lubricating problems and practices, encountered in the steel mill, are mentioned in this paper and possible solutions based on practical methods, are suggested.

The advantages of using centralized oil and grease systems are touched on briefly but no reference is made to any particular type of system or to the advantages of any one system over another.

The writer has attempted to show the importance of proper lubrication and proper maintenance and how they are dependent one upon the other. He has also stressed the importance of close cooperation between the manufacturers of equipment and lubricants, and the operating and engineering departments of the steel companies.

MODERN PIT DESIGN and PRACTICE at FAIRFIELD WORKS

By E. A. HAWK and M. P. BURNS

Fuel Engr. Asst. Fuel Engr.

Tennessee Coal, Iron & Railroad Company

Ensley, Alabama

Abstract of paper to be presented before the A. I. & S. E. Annual Spring Conference, Birmingham, Alabama, March 27-28, 1939.

▲ THE term soaking pit dates back to the early days of the steel industry when heats were small, yielding only a few ingots of relatively small size, which were stripped and placed in the pit while very hot. These pits were not heated, and the process was truly a soaking process.

The gradual change in steel plant operations, particularly as to size and speed, brought about a conversion of the soaking pit into an actual heating furnace. Increasing stringency of quality requirements, however, soon necessitated soaking pit improvement. At first, such improvement took the form of refinement of existing designs, but later development brought pits of radically different design, with complete automatic control of combustion and temperature conditions.

Present soaking pit facilities at Fairfield Works consists of four rows of reversing regenerative pits, four rows of non-reversing pits, and three rows of bottom-fired pits, serving both blooming mills. The last type is described in detail in this paper, including mechanical and electrical phases, and the method of operation is given. The results of an extended temperature survey made on these pits are recorded.

Detailed heat balances, covering different ingot charging temperatures, have been made, showing efficiencies ranging from 29.8 to 54.8 per cent, and averaging 41.3 per cent. Fuel is coke oven gas, and shows operating consumptions ranging 235,000-1,350,000 Btu. per ton, with an average of 400,000. Complete details of the heat balances are tabulated. Fuel input ranges from a maximum of 12,500,000 Btu. per hour down to a holding consumption of 2,000,000 Btu. per hour.

The control system for these pits is described in detail. Temperature in the pits is controlled by thermocouples located in the waste gas stream leaving the furnace, working back to regulate the rate of firing. Fuel-air ratio is automatically controlled for each pit. This ratio is checked in a simple manner, using flow charts which are presented in the article. Furnace pressure on each pit is also automatically regulated, the control functioning to operate a damper in the waste gas flue. Normally, a pressure of .05 in. water column is maintained.

Fuel gas pressure is held uniform by a regulator which controls a butterfly valve in the main gas supply line. Movement of the pit cover automatically stops the fan supplying combustion air. Stopping of the air flow causes the combustion control to shut off the fuel gas supply.

All controls are provided with means for manual operation in case of automatic control failure. Indicating gauges are provided to give guidance for manual operation.

Method of pit operation is discussed. In addition to the regular heater, a technically trained man is in attendance as pit operator, and is responsible for the operation of all controls. This man also keeps a complete record of pit performance, a sample report of which is presented.

Scale formation in the pits is of normal weight, but remarkably uniform over the entire ingot. Very little cinder is formed, so that it is necessary to "clean out" only every three or four weeks. Fresh coke is added at two-day intervals.

A comparison of fuel consumption and rate of production between the automatic pits and the previously existing equipment is made, using a method of compensating for different ingot charging temperatures, and shows fuel on the new pits to be approximately two-thirds of that of the other pits.

Low fuel consumption and uniform heating has featured the operation of the new pits. They have not been in service long enough to indicate the relative cost of maintenance, but all indications are that it will be considerably lower.

MODERN WIRE DRAWING PRACTICE

By J. J. PHIFER, Supt.

Fairfield Wire Works

Tennessee Coal, Iron & Railroad Company

Abstract of paper to be presented before the A. I. & S. E. Annual Spring Conference, Birmingham, Alabama, March 27-28, 1939.

▲ THIS paper is intended as a brief description of wire drawing processes and equipment at present used in the production of round, low carbon wire products. A general definition of wire is given, and the point stressed that all wire is not cylindrical, but may be of numerous other cross sections. Statistics for the last few years are

quoted, indicating that, of a total production of approximately two million tons of wire produced, 475,000 tons went into nails, 7500 tons into coat hangers and 23,000 tons into fly screening, indicative of the widely varied uses for wire products.

The essential elements of a wire drawing mechanism are outlined, with a description of the conventional group-driven rod frame and some of its inherent disadvantages are discussed. Improvement of the mechanism and correction of some of these weaknesses has led up to the present forms of continuous wire drawing equipment, development of which took place in the early 'twenties'.

Improvement in continuous wire drawing equipment was more rapid in copper than in steel, principally because the earlier designs were based on the principle of slippage, which slippage could be tolerated to a greater extent in the wet drawing process used in copper than in the dry process usually practiced in steel. The various types of single spindle and multiple draft wire drawing machines are described, and the relative merits of each type discussed. The types are grouped into two main classifications: those with fixed speed ratios and those with each spindle driven independently by an adjustable speed motor, with preference expressed for the latter type because of its greater flexibility. The application of double deck blocks is discussed, with comments as to the preferred location of this block in the process.

NEW FEATURES AID SAFETY

Modern wire drawing machines incorporate many features which have lightened the manual labor of the wire drawer, increased his earnings and made his work safer. The new machines are self-contained units with high design standards and greatly improved mechanism. Emphasis is placed on safety features, such as slow draw-in-speeds, smooth acceleration, dynamic braking, which are great aids to safety as well as to higher productivity.

The use of welding now limits the size of finished bundle only to capacity of finishing block and to its ultimate use by the finishing departments.

A comparison of wire drawing speeds of old—vs. modern equipment states present speeds as 1000-1500 feet per minute for low carbon, and 450-1000 feet per minute for high carbon, while on the finer gauges in low carbon speeds of 1500-2500 feet per minute are being attained.

The development of tungsten carbide dies is a revolutionery development in which increased die life and resultant improvement in surface finish, accuracy of gauge and increase in size of bundle have improved efficiency and product.

The trend in modern practice is to higher speeds, heavier bundles, improved finish and closer tolerances. Proper rolling and processing, particularly cleaning and coating are vital factors in a successful wire drawing operation. Credit for many of the advances in wire drawing practices is given the steel makers who have provided the wire industry with sound, workable material for their processes. Wire drawing is a severe test of the soundness and uniformity of stock, and the continuous wire drawing process would be a lamentable failure if such qualities in the steel were not available.

RELAY

PROTECTIVE METHODS FOR STEEL MILL SERVICE

By H. A. TRAVERS
Westinghouse Electric & Mfg. Company
East Pittsburgh, Penna.

Abstract of paper to be presented before the A. I. & S. E. Annual Spring Conference, Birmingham, Alabama, March 27-28, 1939.

▲ IT is believed that the increasing use of synchronous motors for various steel mill purposes justifies a general review of the protective features incorporated in the present day control of these machines.

Consideration of the wide load swings and the design characteristics of synchronous motors, especially for main drives, has developed the use of several protective devices. From casual inspection one might wonder why so many different relays are required to adequately protect the motor and service.

A discussion of the reasons back of these various forms of protection is presented. The apparent trend toward the "unattended station" form of protection may desirably release the substation operator for other coordinated duties. The fact that synchronous motors act like generators under short circuit conditions on the supply system, or when there is a sudden loss of load, as when a slab leaves a roughing mill drive, requires that the protective devices shall recognize such conditions, and closely discriminate as to whether the motor should be given the opportunity of "riding through" or be tripped off the system.

There are many types of abnormal conditions for which simple over-current protective relays are not adequate. It is recognizing, distinguishing and responding properly to these varied situations that is involved in this problem. The proper economic balance, as to how far protective measures should be added, usually dictates the solution.

C. Clarke Wales
PRESIDENT

Association of

Iron & Steel Engineers

It is with a keen sense of pleasure that the Association of Iron and Steel Engineers comes to Birmingham for its 1939 Spring Engineering Conference. It has not been our good fortune to previously hold any national function in this district so rich in the materials and traditions of the iron and steel industry, and I am gratified to be able to extend a cordial invitation to the steel men of the Birmingham district to take part in the various activities which have been so ably arranged by the committees from our Birmingham membership.

Birmingham District Committees

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W. J. Wilson
R. R. Thomas
A. W. Hood
Walter Donahue
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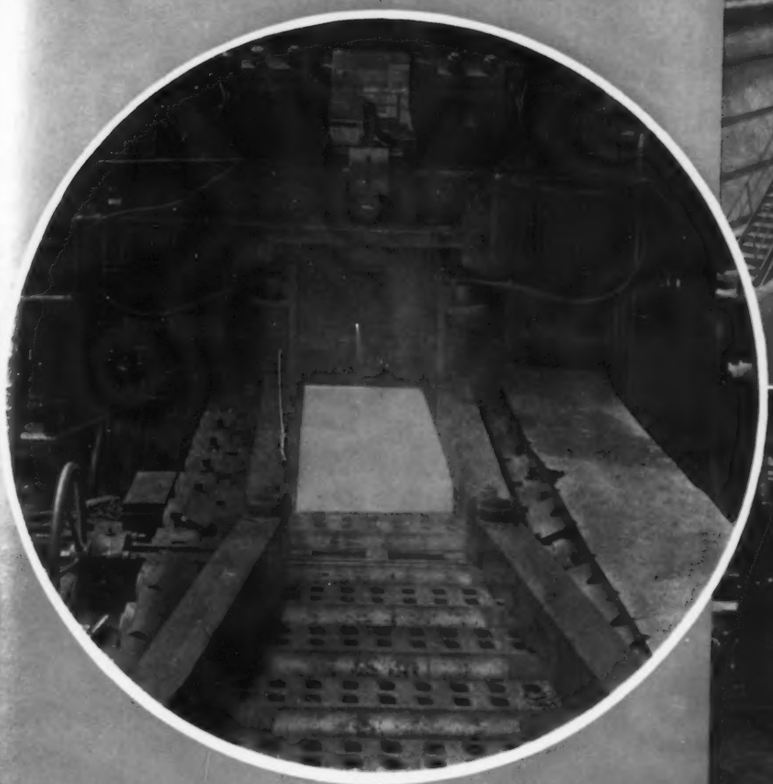
Association of Iron and Steel Engineers



TIN PLATE PRODUCTION at the TENNESSEE COAL, IRON and RAILROAD CO.

TIN PLATE PRODUCTION at the

until today this industry has become a vital factor in the economic life of the South and a vigorous contender in the markets of the world. A major part of the district's capacity is represented by Tennessee Coal, Iron and Railroad Company, with extensive plants at Ensley and Fairfield, employing over 23,000 individuals and manufacturing almost every variety of steel products. This latest expansion provides capacity for the production of 200,000 gross tons of tin plate per year, a new commodity in and a sizeable addition to the company's manufacturing program. Thus, the Tennessee Company operations are expected to gain through further diversification and at the same time offer increased employment due to the new units.

Entry into this new field of production necessitated expansion in various preceding operations, so that the whole tinplate project actually includes expanded mining and steel making activities as well as the construction of new soaking pits, a blooming mill, a hot strip finishing train, and cold reduction tin mills with the attendant finishing equipment. Buildings housing the new improvements cover approximately 22 acres, and required 1,100,000 cu. yd. of excavation, 120,000 cu. yd. of concrete, and 25,000 tons of structural steel.

TENNESSEE COAL, IRON and RAILROAD CO.

By T. J. ESS, assisted by JAMES D. KELLY

THE operations of the new tinplate plant of the Tennessee Coal, Iron and Railroad Company at their Fairfield Works represent another long stride in the evolution of the iron and steel industry in the South. For more than seventy-five years the development and utilization of nature's abundant resources of iron ore, coal and limestone in the Birmingham district have progressed in steps at times somewhat uncertain, at times vigorous,

The new buildings are of standard gable roof design, covered with galvanized corrugated sheets. Where extra protection was desired, a sandwich construction was used, with an insulating material between two corrugated sheets. In each roof slope, glass skylight sections, paralleling the building length, afford natural lighting. These building units, together with data on the cranes serving them, are given in Table 1.

The plant layout, as can be seen from the accompanying maps, is such that material flow is smooth and

constant. In normal production from ingot to tinplate, material is handled entirely by various modern mechanical methods without any recourse to loading, shifting and unloading of railroad equipment.

SOAKING PIT AND BLOOMING MILL

To supply slabs for subsequent rolling on the hot strip mill, a new blooming mill installation has just been completed. Six new soaking pits, 15 ft. square x 9 ft. 6 in. deep have been added to the previously existing facilities. Each pit is faced for a height of 20 in. with 13½ in. of chrome brick, and above this, with 18 in. of silica brick. The top of the pit wall is provided with fire-clay curb blocks which form a groove containing granular ganister for effecting a tight seal. The covers, formed of 9 in. flat suspended arches with 2 in. of insulation, are lifted vertically above the groove before traverse motion begins. They are operated, with suitable inter-locks and limit switches ,from a single point.

The pits are built in three blocks of two holes each. Each block is provided with four 5-pass recuperator chambers, two on each side, of refractory tile design. The waste gases, at temperatures of about 2200 degrees F., travel down the flues, while air to be preheated enters at the bottom through a series of separately adjusted doors. Arches over the recuperators are of 9 in. high-alumina brick, with 2 in. of insulation. Side and end walls of the chambers are of 9 in. brick with 4 in. of insulating block.

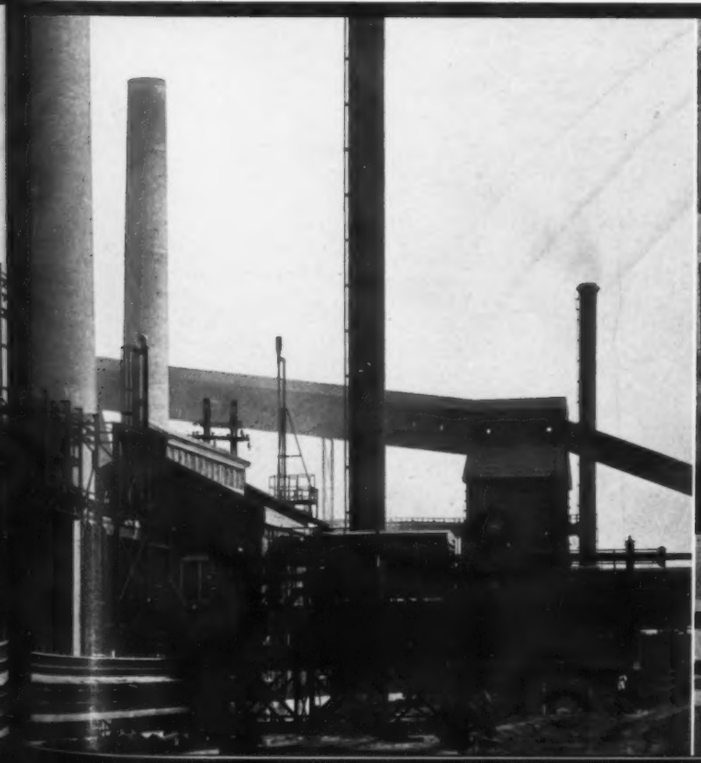
Separate steel ducts are provided for removing the waste gases from each recuperator. Ducts for each pit connect to a common uptake in which is mounted a

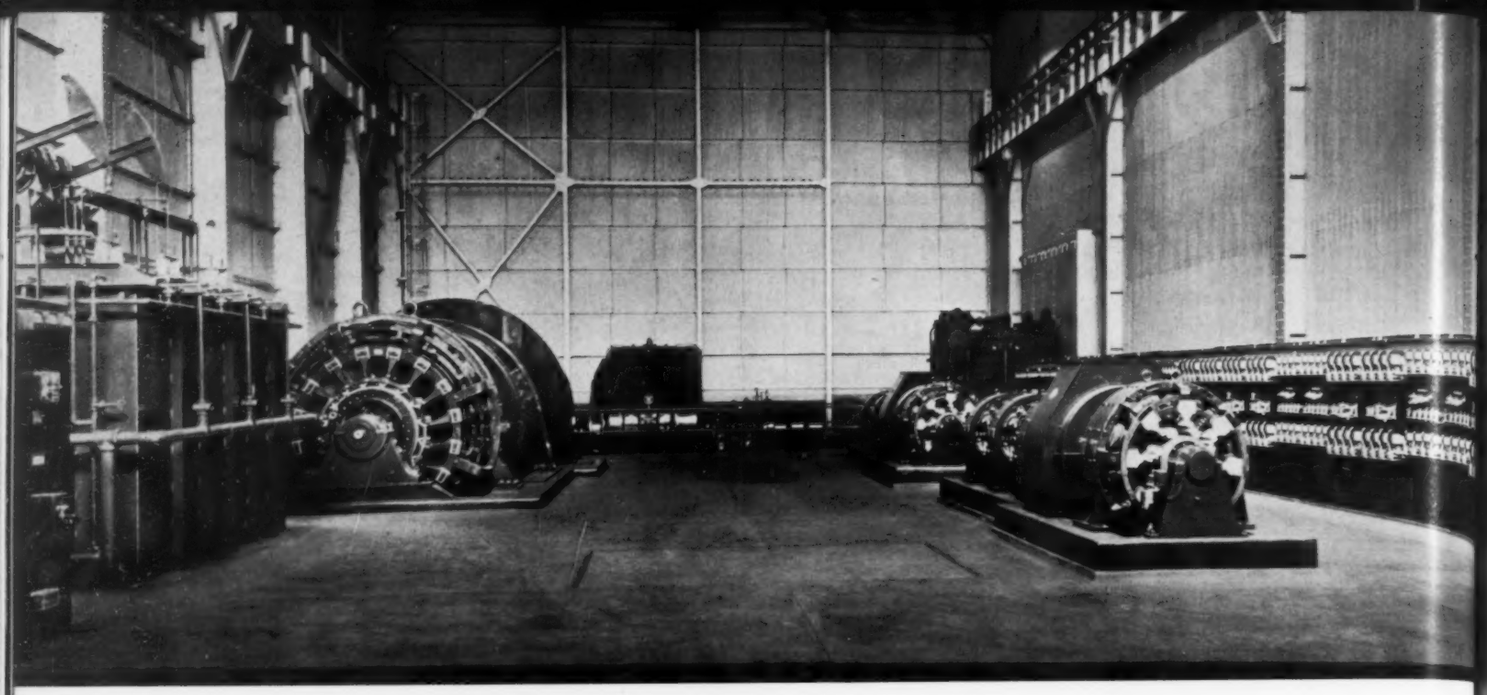
ROBERT GREGG
President

(Lower right) Six new recuperative soaking pits of modern design amplify existing heating facilities for the blooming mills.

●

Two new batteries of coke ovens were installed, consisting of 73 ovens, 37′ 6″ long x 12′ 0″ high x 18¼″ average width. Each oven holds 15.7 tons of coal per charge and is equipped with self-sealing doors.





General view of new blooming mill motor room. To the right are the motor-generator units for Ward-Leonard control of mill auxiliaries.

butterfly valve for controlling stack draft and a manually operated shut-off valve. Ducts are lined with 3 in. of fire brick and 1½ in. of insulation. Each block has a brick-lined stack of 5 ft. in diameter x 100 ft high.

Each battery of two pits and four recuperators is encased with ¼ in. steel plates. Four oval clean-out holes in the bottom of each pit provide means for slag and scale removal.

Each pit is fired in a vertical upward direction through one centrally located port or burner in the hearth, with coke oven gas. Combustion air is supplied to the recuperators from low pressure blowers through a duct system containing manually adjusted blast gates and automatically operated butterfly valves.

Automatic temperature control is effected by thermocouples located in each of the four waste gas outlets in the pit. The average temperature of the four couples is relayed to a recording controller which operates the fuel input valve. An adjustable throttling range on this controller provides anticipatory control. Furnace pressure and fuel-air ratio are also automatically controlled.

The pits will hold 16 ingots 24 in. square, 12 ingots 24 in. x 36 in., 8 ingots 24 in. x 54 in., and 6 ingots 30 x 60 in. The new pits are placed in conjunction with the old pits, so that all pit facilities may feed to either the old blooming mill or the new one.

The new mill is a 2-high reversing 46 in. slabbing-blooming mill, and lies directly in line with the strip mill. The use of rolls with a body length of 104 in., together with the high manipulator and side guards, permits the economical rolling of slabs for use in the new strip mill. The mill is driven by a 7000 hp., 50-100 rpm., 700 volt d-c. motor. The mill receives power from a motor-generator set composed of two 3000 kw., 700 volt d-c. generators, a 5000 hp., 352 rpm., 6600 volt 60 cycle induction motor, and a 79 ton flywheel.

THOMAS CHALMERS

Operating Vice-President

Blooming mill screws are driven by two 150 hp., 450 rpm., 230 volt shunt motors. Side guards are driven by two similar motors, connected permanently in series, as are the front and rear mill tables. The slab shear is designed to cut 7½ in. x 45 in. or 10 in. x 36 in. slabs, and is driven by two 300 hp., 375 rpm., 250 volt shunt motors. All of these mill auxiliaries operate under a Ward-Leonard control system. Two special motor-generator sets supply power for these motors. Each set includes three 150 kw., and one 300 kw., 250 volt d-c. generators, all driven by a 900 hp., 1186 rpm., 6600 volt induction motor. Both sets operate simultaneously, each set supplying with individual generators one screwdown motor, one pair of side guard motors, one pair of table motors and one shear motor. All of these generators have a self-excited shunt field and a heavy series differential field in addition to the usual separately excited shunt field, in order to obtain the desired characteristics.

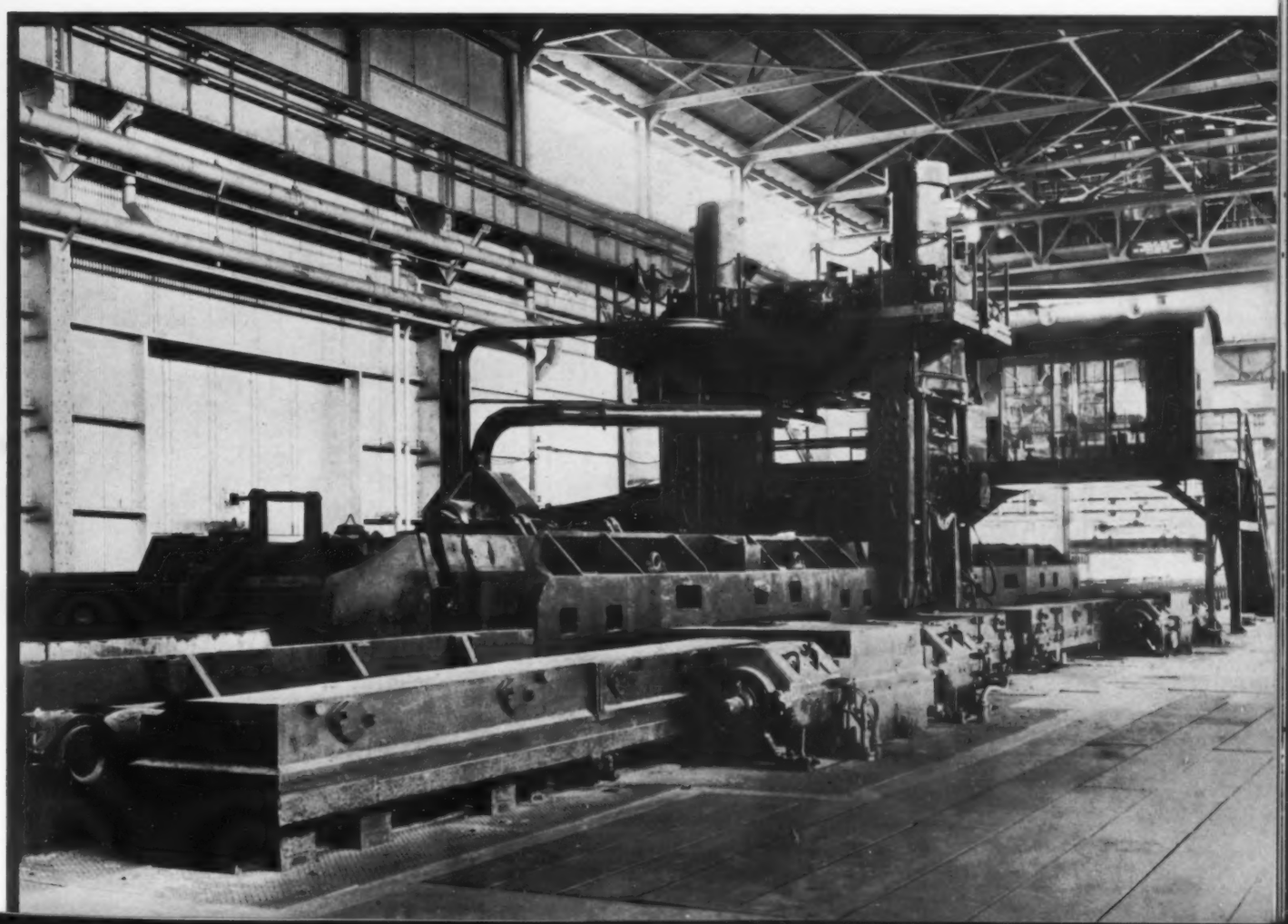
Slabs are transferred from the shear runout table to the chipping yard and piled by means of a pusher and a slab cooling conveyor about 115 ft. long. The conveyor is of the reciprocating type with a five ft. stroke, and is driven by a 150 hp., d-c. motor. Near the discharge end of the conveyor is a slab turnover, operated by a cam arrangement from the main conveyor drive, providing a convenient means for inspection of both sides of the slab.

Material rolled on this mill but not going to the slab chipping yard travels on past the conveyor pusher to an inclined table and pusher, where it is loaded on transfer cars for other destinations.

In the slab yard, slabs are handled by overhead cranes through the chipping beds and on to the maga-

A. B. HASWELL
Assistant to Vice Presidents in Charge of Engineering and Construction

The new 46 in. mill is of the modern "slabbing-blooming" type, and is driven by a 7000 hp., 700 volt d-c. motor.



N. L. VAN TOL
Works Manager

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Three triple-zoned furnaces, of 60 gross tons per hour capacity each, heat slabs for the continuous hot strip mill.

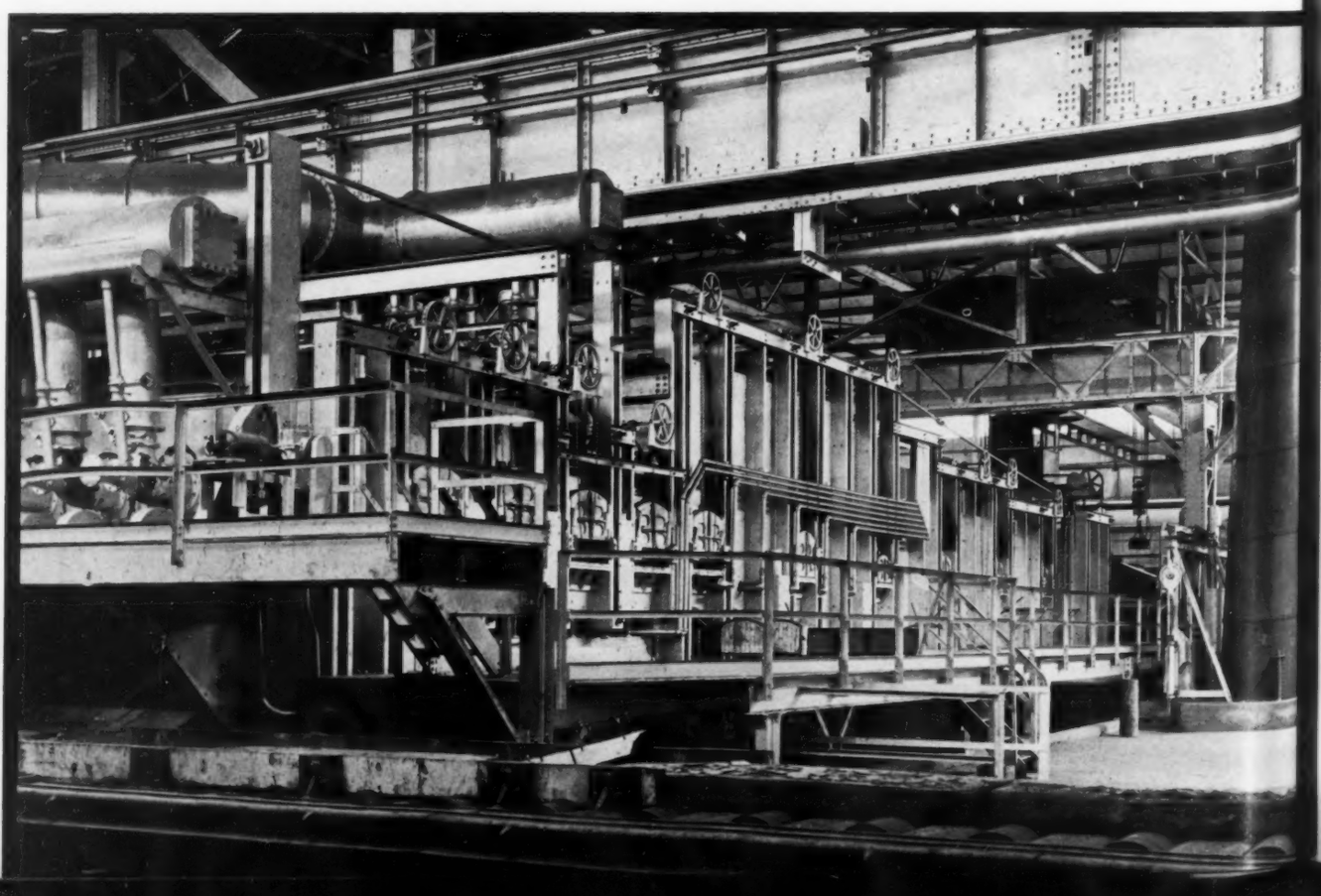
zine depilers located back of each slab heating furnace. The depilers push the bottom slab of the pile forward under an adjustable stop and on to the furnace charging skids. Pushers, two to each furnace, are of the rack type, clutch connected, and driven by 135 hp., d-c. motors.

SLAB HEATING FURNACES

Three continuous triple-fired pusher-type furnaces are installed, with an overall length of 85 ft. 9 in. outside of brickwork. The hearths are 20 ft. in width x 80 ft. in length. Of this length, 17 ft. 6 in. is a solid hearth soaking zone. Nominal furnace capacity is 60 gross tons per hour each, giving a hearth production of 84 lb. of steel heated per hr. per sq. ft. Actual performance has shown this rating to be conservative. The furnaces are fired with coke oven gas through burners of the luminous flame type. The main heating zone, through which slabs are carried on four 3 in. double extra heavy seamless insulated water-cooled skid pipes, is over-fired by six burners and underfired by five. The soaking zone is overfired with six burners. Burner capacity totals about 240,000 cu. ft. per hour, giving a maximum fuel input of 12 to 13 million Btu. per hour.

Flat suspended roofs are used, 9 in. thick, covered with 2½ in. of insulation. Side walls are 13½ in. of firebrick with 4½ in. of insulation, while the hearths are 20½ in. thick, including 5½ in. of insulation. The steel casing of the furnaces is ¼ in. thick.

Two double-pass refractory tile recuperators are incorporated in each furnace, giving 12,900 sq. ft. of heating surface. Waste gases leave the furnace at a temperature of approximately 1800 degrees F., and leave the recuperator at about 1200 degrees F. Air for combustion is heated to temperatures averaging about 650 degrees F. (750 degrees maximum). Air is supplied through a motor-driven fan of 21,000 cu. ft. per min. capacity on each furnace.



Each of the three firing zones of each furnace is equipped with a fuel input control and fuel-air ratio control. Each furnace is also equipped with an automatic furnace pressure control, a temperature control, gas pressure regulators, indicating gas and air flowmeters, and gas and air pressure indicators.

In practice, two furnaces are normally used, with an average production rate of 45 gross tons per hour each. Fuel consumption ar this rate runs about 2,000,000 Btu. per ton, and decreases to about 1,850,000 Btu. per ton at furnace capacity. Under normal operation, approximately 25 per cent of the total fuel input is used in the soaking zone, 45 per cent in the top main heating zone, and 30 per cent in the bottom zone. No hot slabs are charged in to the furnaces.

HOT MILL

The hot mill has a nominal capacity of 37,500 gross tons per month, and is designed to produce No. 18 gauge strip up to 38 in. wide, No. 16 gauge up to 42 in. wide, and No. 14 gauge and heavier up to 44 in. wide. A typical slab size going into the mill would be 30 in. x 216 in. x 6 in. weighing about 12000 lbs.

At temperatures of 2200-250 degrees F., slabs are discharged from the heating furnaces through action of the furnace pushers, and move up to the mill on a roller table 197 ft. 2 in. in length. This table attains speeds up to 600 ft. per minute and is divided into three sections, each driven by a 75 hp., 600 rpm., motor.

The first unit of the mill is a 36 in. vertical edger (of the overhung type) using rolls 9¾ in. long x 38 in. in diameter running in roller bearings. This unit serves well to crack furnace scale which is then removed by hydraulic sprays. It is driven by a 1000 hp., 6600 volt, 600 rpm. synchronous motor through a gear-set with a ratio of 27.6:1, giving a roll speed of 21.7 rpm., with a slab speed of 216 ft. per min. A 50 hp., 230 volt d-c. motor drives the adjustment screws.

Following this at a distance of 82 ft. 8½ in. is located the roughing mill, a previously existing 21 in. and 30 in. x 45 in. three-high universal plate mill which is used in place of the conventional four-stand continuous roughing train. This mill employs cast nickel steel rolls. The horizontal rolls have a 65 in. body length, with a diameter of 30 in. for top and bottom rolls and 21 in. for the middle roll. Vertical rolls of the integral edger are 20¾ in. long x 22 in. in diameter. Composition bearings are used on the top and bottom roll necks,

TABLE 1—BUILDING AND CRANE DATA

	BUILDINGS		CRANES		
	Length	Width	Number	Capacity, tons	Span
Chipping yard runway	725′–0″	104′–0″	2	25/10	100′–0″
Chipping yard runway gantry	200′–0″	25′–0″	1	7½	25′–0″
Hot strip mill	1400′–0″	70′–1½″	1	25/10	66′–1½″
				50/15	66′–1½″
Universal mill motor house	160′–0″	60′–0″	1	25	56′–0″
University plate storage	121′–0″	80′–0″	1	20	76′–0″
Hot strip mill motor house and roll shop	525′–0″	75′–9″	1	50/15	71′–9″
Raw coil storage	680′–0″	90′–0″	1	6	86′–7½″
			1	10	86′–7½″
Discard coil runway	160′–0″	22′–0″	1	3	20′–0″
Raw coil pickling	421′–0″	90′–0″	1	10	86′–7½″
Annealing department	912′–0″	124′–9″	1	10	120′–0″
			2	35/10	120′–0″
Cleaning department	168′–0″	124′–9″	1	10	120′–0″
South cold reduction	552′–0″	69′–9″	2	10	65′–0″
Tin mill roll shop	216′–0″	69′–9″	1	30/10	54′–0″
Cold reduction	552′–0″	85′–9″	2	40/15	81′–0″
North cold reduction	792′–0″	64′–9″	2	10	60′–9″
Shearing department	408′–0″	85′–9″	1	10	81′–0″
White pickling	172′–0″	120′–0″	—	—	—
Palm oil storage	96′–0″	96′–0″	—	—	—
Tinning department	744′–0″	85′–9″	4	3	10′–9″
Tin house repair shop	192′–0″	85′–9″	1	5	81′–0″
Storehouse, metal storage, middling storage and flux house	360′–0″	85′–9″	—	—	—
Assorting room and box house	1008′–0″	74′–9″	1	5	70′–0″
Warehouse	888′–0″	74′–9″	2	5	70′–0″
Loading building	792′–0″	28′–2″	—	—	—

C. R. BOTTENFIELD
General Superintendent

with bronze on the middle roll and on the vertical edging rolls. The roughing mill is driven by a 4000 hp., 800 volt, 80-160 rpm., d-c. motor, giving a slab speed of 464-928 ft. per min. A single 75 hp., 230 volt d-c. motor actuates the main screwdown, while vertical roll adjustment is effected by two 50 hp., 230 volt d-c. motors.

The universal rougher is equipped with preset automatic control for the horizontal screwdown, allowing advance setting of each pass through the mill. The automatic equipment consists of the following:

A reversing dynamic braking magnetic control panel which directly controls the screwdown motor.

A pass selector panel on which is mounted eleven selsyn units corresponding to the eleven passes, as well as a differential relay which operates the magnetic control panel.

A selsyn unit driven by the screwdown mechanism, transmitting actual roll setting to the differential.

A pass selector master controller by which the operator actuates the automatic control.

A transfer master which allows the operator to change from automatic to manual operation at any time.

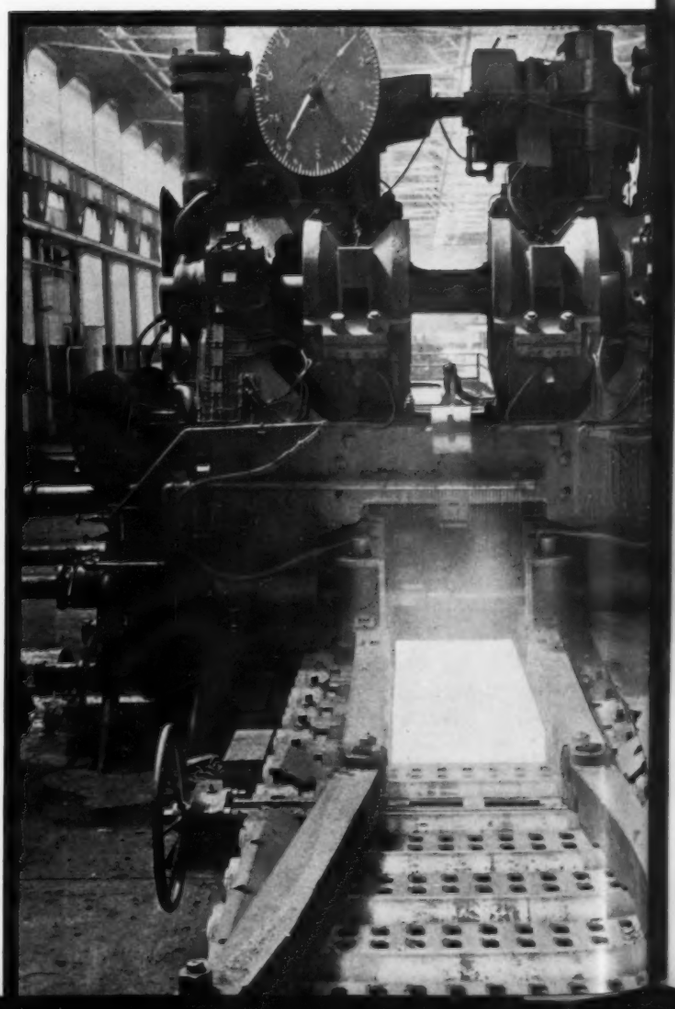
A manual master control for non-automatic operation of the screwdown control panel.

This device is designed to control the reduction of slabs from a maximum thickness of 8 in. to any desired final thickness in eleven or less passes. The operator first sets the dials corresponding to the passes. When the pass selector master is set in position No. 1, the No. 1 pass selsyn unit and the mill selsyn unit are connected to the differential relay, which causes the screwdown motor to move the rolls until the selsyn geared to the screwdown corresponds with the No. 1 pass selsyn. Subsequent moving of the master to the following positions brings the roll settings automatically to the advance setting through the entire schedule of reduction. Return of the master to the No. 1 position opens the rolls to the inital setting.

No broadside rolling is done on this mill, inasmuch as slabs of maximum width may be obtained from the blooming mill. Therefore there are no turntables, slab pusher or slab squeezer required.

The handling and shipping facilities of the universal plate mill were retained, so that the mill may still be used for plate production. When rolling this product, a chain-type transfer, approximately 100 ft. x 65 ft., serves as a cooling bed and moves the plates from the mill table to a second parallel table on which is installed a plate leveler and a $1\frac{1}{8}$ in. x 48 in. shear. After shearing to desired lengths, the plate passes on to storage skids for shipping. When rolling strip, however, the break-down, with a thickness of about $\frac{3}{4}$ in., passes on down the mill table. Approximately half way between

A three-high universal plate mill, driven by a 4000 hp., 800 volt d-c. motor, serves as a rougher in the hot strip mill.



the rougher and the finishing is a 48 in. x 1⅛ in. shear for cropping.

The finishing train is placed about 420 ft. from the universal rougher, and consists of the conventional scalebreaker and six finishing stands, all spaced on 20 ft. centers. The scalebreaker, is a two-high 32 in. x 48 in. stand, driven by a 500 hp., 150-450 rpm., 600 volt d-c. motor. The six finishing stands are all four-high, 21½ in. and 48 in. x 48 in., each driven by a 600 volt d-c. motor. No. 1 and 6 use 2500 hp., 175-350 rpm. motors, No. 2 and 5, 3000 hp., 150-350 rpm. motors, No. 3 a 3500 hp., 175-350 rpm. motor, and No. 4 a 3500 hp., 125-250 rpm. motor.

Gear ratios and mill speeds in the finishing train are as follows:

	Gear ratio	Roll speed, rpm.	Strip speed ft. per min.
Scalebreaker.....	15.08	9.94– 29.84	84– 252
No. 1 Finisher....	6.2	28.2 – 56.4	159– 318
No. 2 Finisher....	3.44	43.6 –101.6	245– 572
No. 3 Finisher....	2.15	81.2 –162.4	457– 914
No. 4 Finisher....	Direct	125. –250	704–1407
No. 5 Finisher....	Direct	150. –350.	844–1970
No. 6 Finisher....	Direct	175. –350.	985–1970

Oil film bearings are installed on the scalebreaker and the back-up rolls of the finishers. Roller bearings are

A. H. CHALMERS
Assistant General Superintendent

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The 48 in. finishing train consists of a scalebreaker and six finishing stands spaced on 20 feet centers, and driven by 600 volt d-c. motors.

applied to the work rolls, while all pinion stands and gear sets employ babbitt bearings. Cast chilled molybdenum work rolls are used in the first two finishers, with cast chrome steel in the last four. All back-up rolls are of cast nickel steel.

Between each stand in the finishing train strip is carried by five individually driven centrifugally cast alloy iron table rollers, manually controlled, as follows:

Scalebreaker to No. 1 finisher—Five gearmotors, 300-1200 rpm., 110-440 volts, 15-60 cycle, 3 phase, 12:1 ratio.

View of the finishing train motor-room, which houses main drive motors and their gear sets, as well as the motor-generator sets for this train.

R. D. OSGOOD
Chief Engineer

No. 1 to No. 2 finisher—Five gearmotors 180-720 rpm., 110-440 volts, 15-60 cycle, 3 phase, 4.46:1 ratio.

No. 2 to No. 3 finisher—Five gearmotors 180-720 rpm., 110-440 volts, 15-60 cycle, 3 phase, 2.88:1 ratio.

No. 3 to No. 4 finisher—Five squirrel cage motors, 112-450 rpm., 110-440 volts, 15-60 cycle, 3 phase.

No. 4 to No. 5 finisher—Five squirrel cage motors, 150-600 rpm., 110-440 volts, 15-60 cycle, 3 phase.

No. 5 to No. 6 finisher—Five squirrel cage motors, 180-720 rpm., 110-440 volts, 15-60 cycle, 3 phase.

Between each of the finishing stands, actuated by an 8 in. double acting air cylinder of 23½ in. stroke controlled by a solenoid operated four-way valve with push button control, a looper serves to take up any slack which might occur between stands.

Finishing stand screwdown motors are mounted on top of the mill housings, and may be operated separately or, through magnetic clutches, in unison. Two 15 hp., 750 rpm., 230 volt d-c. motors are used on the scale breaker, and two 35 hp., 590 rpm., 230 volt d-c. motors on each of the finishers.

Careful watch is kept on the temperature of the strip as it passes through the hot mill. For this purpose, four recording radiation pyrometers are installed, one between the vertical edger and the universal mill, one just ahead of the finishing scalebreaker, one just beyond No. 6 finishing stand, and one just ahead of No. 1 coiler. Close regulation of temperature at these points is important to assure constant physical and metallurgical characteristics of the strip.

Hydraulic descaling sprays remove scale from the strip and insure good product surface. They are located after the vertical edger and after the finishing scalebreaker, and are controlled by 4 in. hydraulic valves operated through a pneumatic cylinder with solenoid control. Three multi-stage centrifugal pumps. Each of 1000 gpm. capacity at 1300 lb. per square in. pressure, supply water for descaling. Each is driven by a 1250 hp., 1750 rpm., 6600 volt, 60 cycle induction motor. These pumps are located in a pump room at the end of the finishing mill motor house. Approximately 600 gallons of water per ton of strip rolled is consumed in the descaling operation.

Hydraulic roll balance is furnished from two separate systems. The 500 lb. pressure system on the universal rougher, which existed previous to the expansion program, has its own pump and accumulator. A new 1500 lb. system, with separate pump and accumulator, was installed for the finishing train.

A typical rolling schedule, on the hot mill, producing .074 in. strip, is as follows:

UNIVERSAL MILL

Pass	Initial thickness, in.	Per cent reduction of area.
1	7.18	8
2	6.60	9
3	6.00	10
4	5.40	7
5	5.00	12
6	4.40	11
7	3.90	13
8	3.40	12
9	3.00	13
10	2.60	12
11	2.30	17
12	1.90	24
13	1.45	24
14	1.10	18
15	.90	11

FINISHING TRAIN

Pass	Initial thickness, in.	Per cent reduction of area.
Scalebreaker	.800	0
1	.800	47
2	.425	45
3	.235	47
4	.125	28
5	.090	12
6	.079	6

L. E. STEVENS
Superintendent, Hot Strip Mill

The average hourly rolling on tin mill strip is about 85 gross tons, although an hourly production of as much as 162.6 gross tons has been attained. Power consumption of the hot mill averages somewhat as given below:

42 in. universal mill drives	13.9 kwh. per ton
42 in. universal mill aux.	15.4 kwh. per ton
48 in. finishing train drives	60.2 kwh. per ton
48 in. finishing train aux.	24.5 kwh. per ton
Total power consumption	114.0 kwh. per ton

All strip produced leaves the hot mill in coil form, there being no facilities for cutting up strip at the end of the mill. Finished gauge averages about .070 in.

Leaving the last finishing stand, strip is conveyed to the coilers, over 400 ft. distant, on a runout table consisting of 203 centrifugally cast alloy iron rollers, 10 in. in diameter x 48 in. face, equipped with self-aligning roller bearings, and spaced on 24 in. centers. The

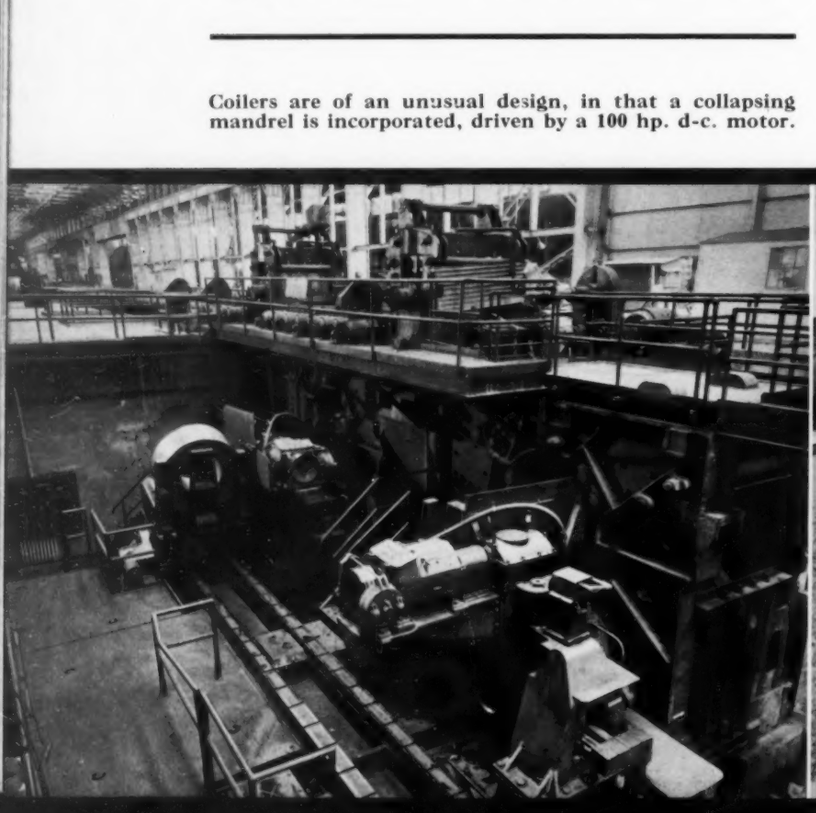
The runout table, over 400 feet long, is composed of 203 rollers, individually driven by variable frequency motors.

H. C. KAEFF
Superintendent, Cold Reduction

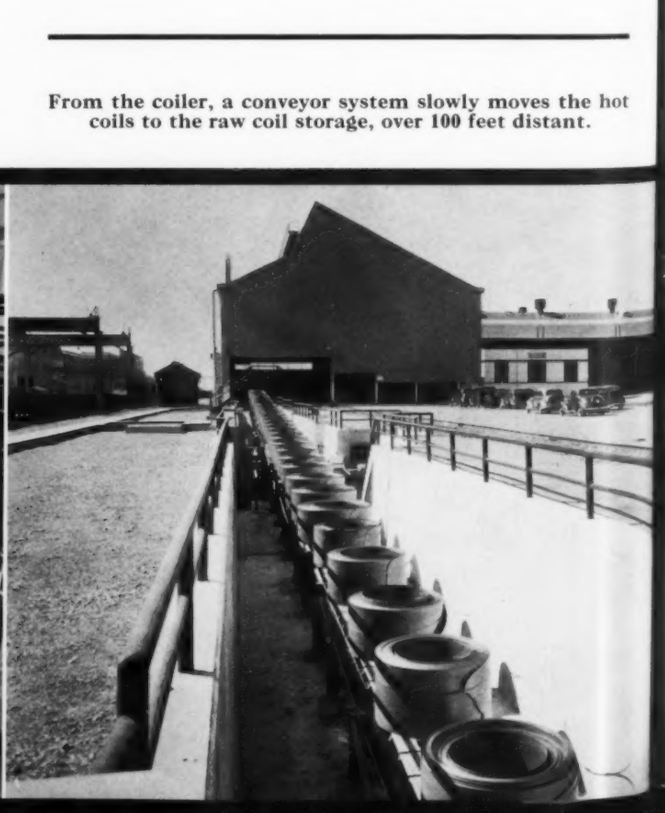
rollers are connected through light duty couplings to individual squirrel cage motors, 1.67-5.0 hp., 300-900 rpm., 20-60 cycle, 147-440 volts, 3 phase. The motors are fully enclosed, fan cooled and are equipped with ball bearings. Adjustable side guards with a range of travel from 16 in. minimum to 47½ in. maximum center the strip on the table as it nears the coiler pinch rolls.

The two coilers can accommodate material in widths ranging 16-44 in., of No. 18-7 gauge, forming coils 30 in. minimum inside diameter x 60 in. maximum outside diameter at a maximum speed of 2100 ft. per minute. Each unit consists of a set of deflecting pinch rolls 20 and 36 in. in diameter, a set of guding pinch rolls 12 in. in diameter, and eight blocking rolls 12 in. in diameter, all 48 in. long. The blocking rolls are arranged around a 30 in. x 48 in. collapsing mandrel. Only the first two blocking rolls are driven, the others acting as idlers. The guiding pinch rolls are not in use, having been found unnecessary. The strip enters the deflecting pinch rolls, which are mounted on the runout table, and is deflected down to the coiling mandrel. The mandrel and the deflecting pinch rolls are each driven by a 100 hp., 600-1200 rpm., d-c. motor.

Coils are pushed from the coiler mandrels by strippers, and deposited on up-enders which in turn rotate through 90 degrees and place the coil on a chain-type conveyor system. This system, which consists of eight conveyors extending over 1000 feet in a straight line paralleling the runout table, carries coils to the raw coil storage. Conveyors No. 1 and 8 travel 72 ft. per min., while No. 3, 4, 5, and 6 travel at a rate of 18 ft. per min. Conveyors No. 2 and 7 are driven by d-c. motors with controls arranged for two speed operation so as to work with both of the adjacent conveyors. Coils are spaced on the conveyor at 7 ft. 6 in. intervals, and when handling 30 coils per hour, require about four hours to complete the travel. This period allows time for a very considerable degree of cooling of the coil before storage. A scale located under No. 3 conveyor registers weights as the coils progress. The final conveyor delivers the coils to a down tilter and on to a gravity conveyor, which allows the coils to ride to a stop where they are taken up for placing in storage.



Coilers are of an unusual design, in that a collapsing mandrel is incorporated, driven by a 100 hp. d-c. motor.



From the coiler, a conveyor system slowly moves the hot coils to the raw coil storage, over 100 feet distant.

Two duplicate continuous pickling lines form the raw coil pickling department with a nominal capacity of 28,000 tons per month.

Brakes on the gravity conveyor serve to regulate the speed of the coil movement. While transferring the coils, this system also raises them some 15 feet in grade level.

MOTOR ROOM

Two separate motor-rooms house the hot mill drives. The first of these serves the universal rougher, and contains the 4000 hp. motor driving this mill. Power is supplied to this motor from a motor generator set consisting of two 1750 kw., 800 volt d-c. generators driven at 514 rpm. by a 4900 hp., 6600 volt, 60 cycle synchronous motor, separately excited by a four-unit set. This mill is controlled by variable voltage up to base speed, with field control above base speed.

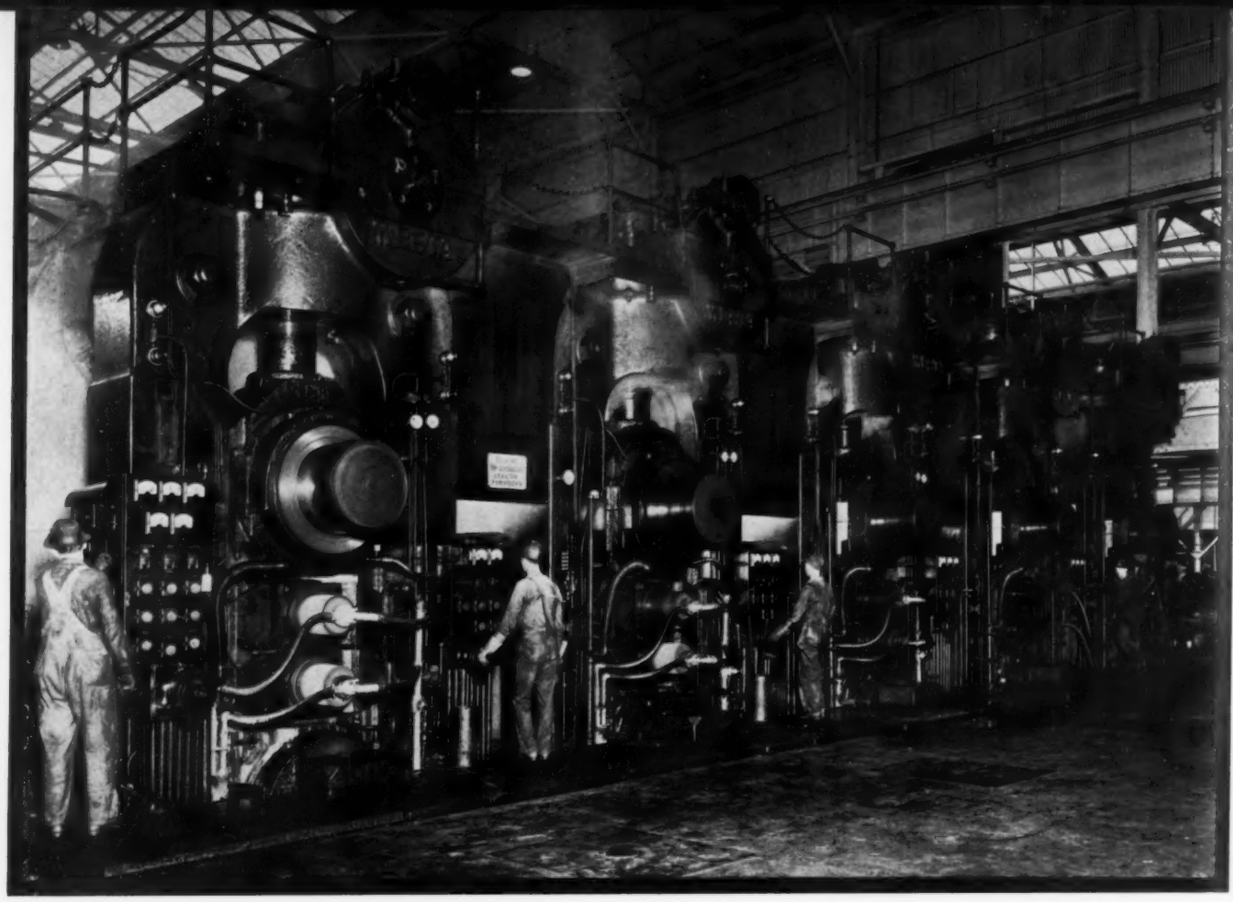
Direct current for general auxiliary use is furnished by three 750 kw., 250 volt d-c. generators, each driven by a 1080 hp., 6600 volt, 60 cycle, 900 rpm. synchronous motor.

The vertical edger drive, which is placed just outside of this room in the hot mill building, is started directly across the line.

Located just outside of this motor-room is a bank of three 6600-240 volt transformers totaling 1500 kva., for auxiliary power and lights, while another 1500 kva. bank, located on the other side of the mill, supplies power for a water pumping station.

The second motor-room houses all the main drives of the finishing train, together with their gear sets. These drives receive power from two motor-generator sets, each consisting of two 3000 kw., 600 volt d-c. generators driven by an 8400 hp., 6600 volt, 60 cycle, 360 rpm. synchronous motor. One of these sets also includes a 250 kw., 250 volt exciter, while the other

H. C. RODGERS
Superintendent, Tin House



There are two five-stand cold reduction mills, 20 in. and 53 in. x 42 in., with a maximum delivery speed of 1565 feet per minute.

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E. F. HARRIS
Plant Metallurgist

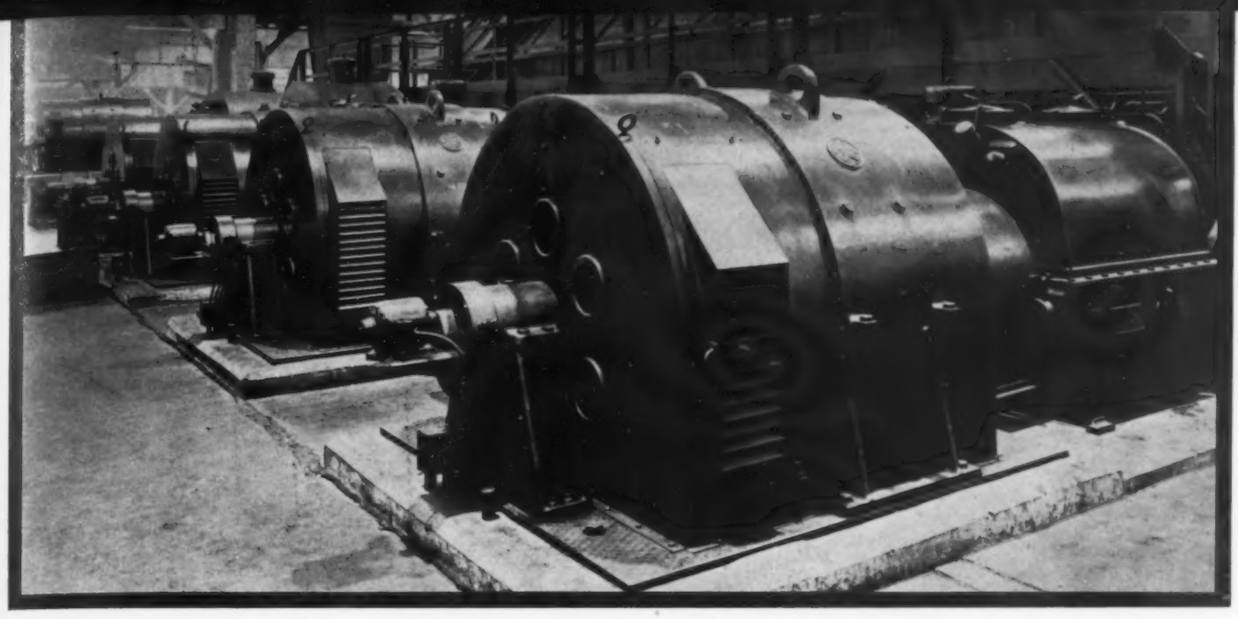
carries a 750 kw., 250 volt generator for auxiliary d-c. power.

Grouped here are also a number of smaller auxiliary motor-generator sets. Three of these, of 11-44 kva., 110-440 volts, 15-60 cycle with a 30-40 hp., 300-1200 rpm., 230 volt d-c. motor, feed power to the short tables between the finishing stands. Four other small sets provide generator voltage control and excitation control for the finishing train.

Coiler motors receive power from two variable frequency sets, located in a control room near the coilers, each composed of a 167-500 kva., 147-440 volt, 20-60 cycle generator for the blocking roll motors, a 200 kw., 250 volt d-c. generator for the pinch roll and mandrel motors, and two 100-200 hp., 400-1200 rpm., 300 volt d-c. motors connected in series, and powered from the 600 volt d-c. bus. Two more, of 167-500 kva., 147-440 volts, 20-60 cycles with two 100-200 hp., 400-1200 rpm., 300 volt d-c. motors connected in series, supply power to the runout table motors. A 60 kw. set provides dynamic braking for the coilers.

All large electrical units in the hot strip motor room are cooled by means of a down-draft ventilation system. Recirculation is effected by four 75,000 cu. ft. per min. motor-driven fans, through four surface-type air coolers. Make-up air is drawn through a 65,000 cu. ft. per min. air filter by a 52,000 cu. ft. per minute fan. A 1500 kva. bank of 6600-240 volt transformers supplies power for auxiliaries and lights in the runout end of the mill, while a 225 kva. bank serves the coil conveyor.

At the end of the finishing mill motorhouse and utilizing the same electric overhead traveling crane is the hot strip mill roll shop, containing equipment for properly maintaining hot mill rolls. There is one 60 in. x 240 in. roll grinder, one 28 in. x 216 in. roll grinder, one milling



Each cold reduction mill is driven by five 600 volt d-c. motors, one of 500 hp. and four of 1250 hp.

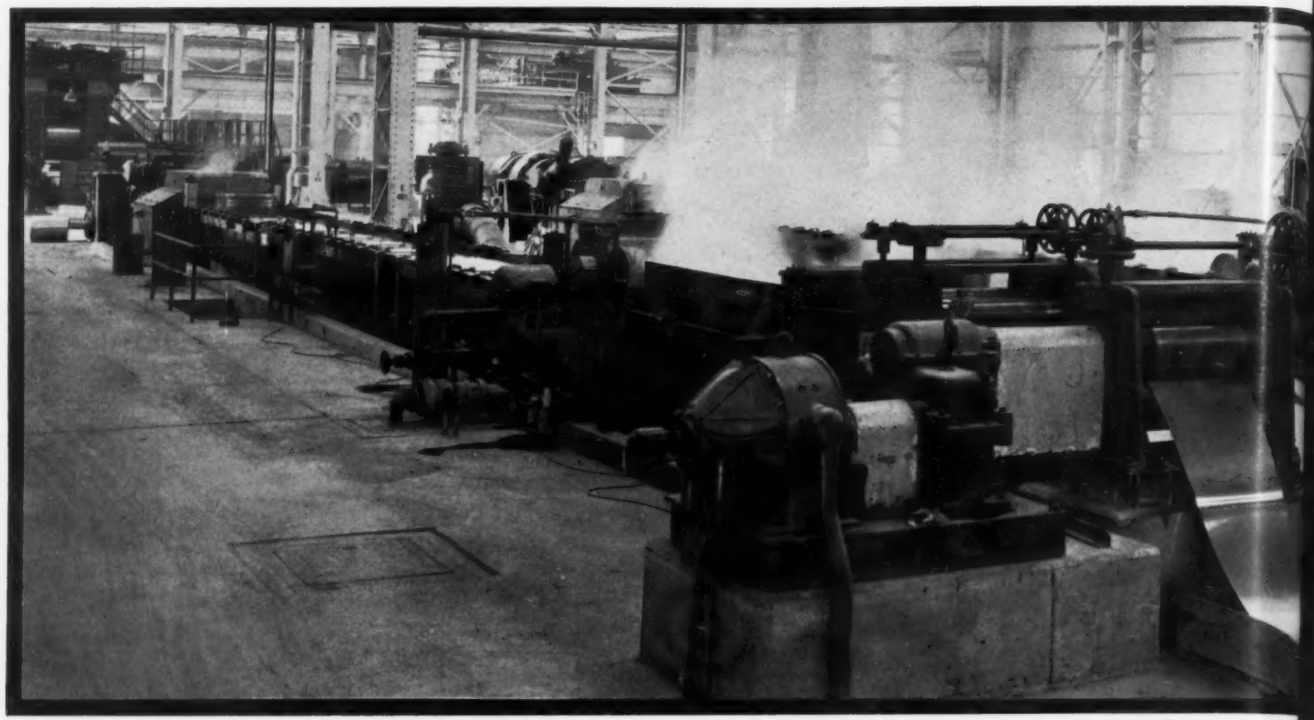
machine, and a degreaser 48 in. x 48 in. x 36 in. deep, wherein work is handled in baskets or by hooks and sprayed by a solvent.

CONTINUOUS PICKLING

The raw coil pickling building runs at right angles to the coil storage and to the cold reduction department, and connects into each of these buildings. Here are housed two duplicate 36 in. continuous pickling lines of an overall length of about 541 ft. Each line consists of a processing uncoiler, an up-cut shear and a stitcher, followed by the usual looping pit, pinch rolls, etc. Next follow three acid tanks, each 59 ft. 8 in. long x 4 ft. wide x 3 ft. 6 in. deep, with a capacity of 6270 gallons, and two water tanks 25 ft. 8 in. long x 5 ft. 5 in. wide

A. L. FRERET
Chief Electrical Engineer

D. G. HOLT
Superintendent of Maintenance



Four continuous electrolytic cleaning lines remove the oil film, left on the strip in the cold reduction process, before it is annealed.

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M. P. MELLON

Construction Engineer

x 3 ft. 10 in. deep with a capacity of 4000 gallons each. The acid tanks are of steel plate construction, lined with a rubber coating and with two courses of acid resisting brick. The water tanks are of welded steel plate, unlined. Tank covers are also of welded steel, with a rubber lining for the acid tank covers only. The acid tanks and the hot water tank are vented to the outside through 16 in. rubber lined pipes by 30 in. rubber lined fans for each tank.

Strip travels through the pickling lines in a speed range of 40-175 ft. per min. Solutions are approximately 15 per cent sulphuric acid, and are maintained at about 195 degrees F. by steam through a circulating jet under automatic temperature control. Average output is about 25 tons per line per hour. Pickling loss runs approximately .7 per cent on a gauge averaging .074 in. Nominal monthly departmental capacity is 28,000 gross tons.

A dancer roll, placed in a vertical supporting housing which allows the roll to move up and down, rides on the strip between the tanks and the recoiler, its movement making the required field current adjustment to maintain the strip in the proper position through the pickle line.

COLD MILLS

The cold reduction department is composed of two duplicate tandem mill trains, each composed of five four-high 20 in. and 53 in. x 42 in. stands, spaced on 13 ft. centers. The first stand is driven by a 500 hp. motor, and each of the last four stands by a 1250 hp. motor, all of 600 volts d-c. Roller bearings are used on the forged steel work rolls, with oil-film bearings on

All material is annealed in coil form in thirty-six radiant tube type annealing furnace fired with natural gas.

the cast steel back-up rolls. Pinions and gear sets are all equipped with babbitt bearings.

Speeds of these mills are as follows:

	Motor rpm.	Gear ratio	Roll rpm.	Strip speed, ft. per min.
No. 1 Stand	450/1050	14.83	30/71	159– 371
No. 2 Stand	350/790	6.27	56/126	292– 660
No. 3 Stand	350/790	3.91	90/202	469–1068
No. 4 Stand	350/790	2.94	119/269	623–1419
No. 5 Stand	350/790	2.64	133/299	674–1565

Screwdowns on each stand are driven by two 35 hp., 590 rpm., 230 volt d-c. motors. The delivery reels are driven by 250 hp., 300-1350 rpm., 600 volt d-c. motors. Automatic strip gaugers are used, and strip tension indicators are installed.

Power for these mills is supplied from two-motor-generator sets, each consisting of two 2500 kw., 600 volt d-c. generators, a 100 kw., 230 volt exciter, and a 75 kw., 200 volt booster generator for the delivery reel, all driven at 514 rpm. by a 7050 hp., 6600 volt synchronous motor.

There is no cold mill motor house, the motor generator sets for these units being located in the cold mill buildings. Cold mill units are cooled by forced draft coming from a basement held under pressure by frou 75,000 cu. ft. per min. fans.

Located at strategic points are three 1500 kva. banks of 6600-240 volt transformers, supplying power for auxiliaries and lights in the finishing departments.

These mills average about 25 tons per hour, reducing

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L. R. RENNER

Superintendent, Assorting and Warehouse

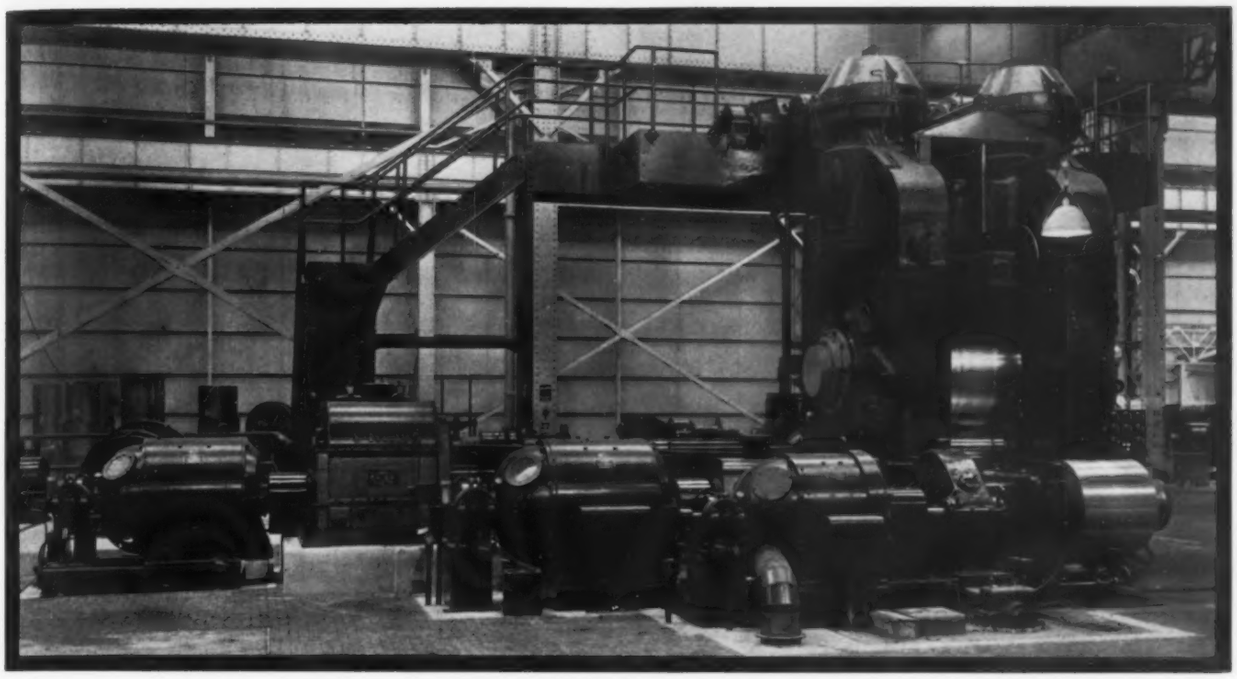
strip gauge from .074 in. to .01 in. Widths of 16-36 in. may be handled, with final gauges of .007-.037 in. Power consumption runs about 97.8 kwh. per ton for the main drives, and 8.9 for the auxiliaries, totaling 106.7 kwh. per ton. Departmental capacity is rated at 25,000 tons per month.

Each of the cold reduction mills is equipped with an exhaust system for removing the vapors which rise from the coolant used in the process. The drive side of the mill is enclosed for the full length by a 1/8 in. steel hood fitted closely all around so as to form a colldcting chamber. Intakes convey the vapors to an under-ground duct leading to a 65,500 cu. ft. per min. motor-driven fan, which in turn exhausts above the roof through a stack. Steam sprays are provided throughout the system for fire protection.

A roll shop is conveniently located to the cold mills, and houses one 60 in. x 192 in. and two 24 in. x 192 in. roll grinders, with the necessary roll racks and other equipment for cold roll maintenance. There is also sand blast equipment complete with all necessary auxiliaries including screw conveyor, elevator, abrasive classifier, three pressure tank machines, roll car and nozzle carriage drives, and dust collecting system Equipment is also installed in the Fairfield Steel Works'

TABLE 2—MILL DATA

Mill	Characteristics	Work roll diam.	Back-up roll diam.	Roll Length	MOTOR hp.	MOTOR Voltage	MOTOR rpm.	MOTOR Type	Remarks
48″ HOT MILL									
Scalebreaker	Vertical edger	38″	.....	9¾″	1000	6600	600	Synchronous	Geared.
Universal rougher	3-high, 1-stand	30″ Top and Bottom	.....	65″					
		21″ Middle	.....	65″	4000	800	80–160	d-c.	Direct.
		22″ Vertical	.....	20¾″					
Finishing scalebreaker	2-high, 1-stand	32″	.....	48″	500	600	150–450	d-c.	Geared.
No. 1 Finisher	4-high, 1-stand	21½″	48″	48″	2500	600	175–350	d-c.	Geared.
No. 2 Finisher	4-high, 1-stand	21½″	48″	48″	3000	600	150–350	d-c.	Geared.
No. 3 Finisher	4-high, 1-stand	21½″	48″	48″	3500	600	175–350	d-c.	Geared.
No. 4 Finisher	4-high, 1-stand	21½″	48″	48″	3500	600	125–250	d-c.	Direct.
No. 5 Finisher	4-high, 1-stand	21½″	48″	48″	3000	600	150–350	d-c.	Direct.
No. 6 Finisher	4-high, 1-stand	21½″	48″	48″	2500	600	175–350	d-c.	Direct.
COLD REDUCTION (Two duplicate tandem mills as follows:)									
No. 1 Stand	4-high, 1-stand	20″	53″	42″	500	600	450–1050	d-c.	Geared.
No. 2 Stand	4-high, 1-stand	20″	53″	42″	1250	600	350–790	d-c.	Geared.
No. 3 Stand	4-high, 1-stand	20″	53″	42″	1250	600	350–790	d-c.	Geared.
No. 4 Stand	4-high, 1-stand	20″	53″	42″	1250	600	350–790	d-c.	Geared.
No. 5 Stand	4-high, 1-stand	20″	53″	42″	1250	600	350–790	d-c.	Geared.
Reel					250	600	300–1350	d-c.	Geared.
TEMPER MILLS (Four duplicate tandem mills as follows:)									
Entry drag generators					(2) 50 kw.	225	450–1200	d-c.	
No. 1 Stand	4-high, 1-stand	18″	42½″	42″	200	316	600–1500	d-c.	Geared.
No. 2 Stand	4-high, 1-stand	18″	42½″	42″	200	316	550–1250	d-c.	Geared.
Tension rolls					200	316	550–1250	d-c.	
Reel					200	316	600–1500	d-c.	
Single stand temper mill	4-high, 1-stand	18″	49″	48″	300	316	400–1000	d-c.	Geared.
Tension rolls					300	316	400–1000	d-c.	
Reel					200	316	600–1500	d-c.	
Entry drag generator					(2) 50 kw.	225	450–1200	d-c.	Gearmotor.



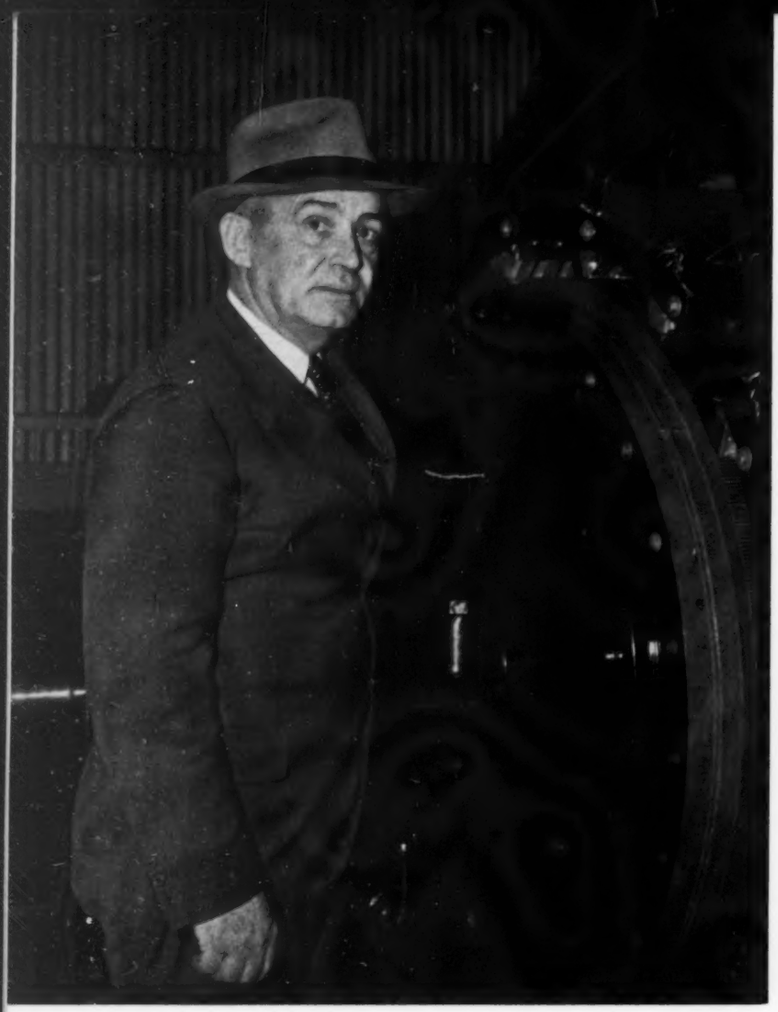
The single stand temper mill is so arranged that it can also be used as a two-high mill for processing drum stock.

roll shop which may be used for cold mill roll maintenance.

ELECTROLYTIC CLEANING

To remove the film of oil which remains on the strip after cold reduction, the strip is passed through a continuous cleaning line. There are four of these units, of 180 ft. overall length, capable of handling strip up to 36 in. wide. An uncoiler pays out the strip, which is fastened to the preceding and following strips by an electric lap welder and progresses through a washer, an electrolytic cleaning unit, a scrubber, a hot rinse tank and drying equipment. Strip travels in a speed range of 210-840 ft. per min. under the action of master pinch rolls at the exit end of the line, while tension rolls control the recoiling operation. The lines operate under variable voltage control from motor generator sets made up of a 75 kw., 250 volt d-c. generator for power for

Temper mill equipment consists of four two-stand tandem mills and one single stand mill, with a nominal capacity totaling 23,000 tons per month.



H. T. WHITE
Superintendent
Mechanical and Electrical Departments

pinch roll, drag and reel motors, a 4 kw., 25 volt booster for the pinch rolls, a 5 kw., 250 volt exciter, and a 125 hp., 220 volt, 1160 rpm. induction motor. Power for the electrolytic process comes from 60 kw., 16 volt d-c. generators driven by 100 hp., 220 volt induction motors, two units being installed for each line.

The cleaning lines have a total capacity of 24,000 gross tons per month.

ANNEALING

Equipment for box annealing is entirely of the radiant tube type. There are thirty-six annealing covers, fired with high pressure natural gas through automatic proportioning mixing burners into eighteen vertical tubes on each side of the cover. The furnaces have effective dimensions of 14 ft. 4 in. length x 6 ft. 6 in. width x 6 ft. 2 in. height, and are charged with eight to sixteen coils totaling an average charge of 44 tons. All material is annealed in coil form. There are 108 furnace bases installed in three rows running the length of the building. Between rows there is a track upon which transfer cars run, materially reducing overhead crane duty in this department.

Annealing cycles average about 44 heating hours, 4 hours soaking time, and 52 hours cooling time before the inner cover is removed, with an annealing temperature averaging about 1265 degrees F. Each cover is equipped with a six-point recording proportional temperature controller, while indicators with selector switches provide instantaneous readings of the various thermocouples. Fuel consumption averages 1480 cu. ft. of natural gas per ton annealed. The department is rated at 22,500 gross tons monthly capacity.

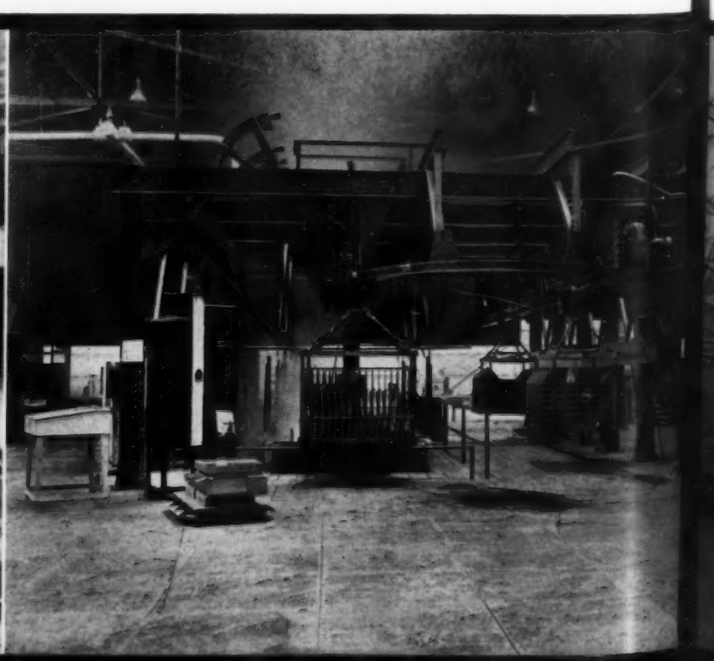
Four gas cracking units, each of 6000 cu. ft. per hour capacity, supply a conditioned gas for the deoxidizing atmosphere used in the annealing process.

TEMPER MILLS

To flatten and condition the surface of the soft annealed strip, it is passed through the temper or skin-pass mills, where a slight reduction, usually less than 4 per cent, is effected. This equipment consists of four tandem mills and a single stand mill. Each of the former consists of two four-high 18 in. and 42½ in. x 42 in.

(Left) Eight shearing lines, operating under variable voltage control, trim the coil, cut it into lengths, and assort and pile the sheets.

(Below) After shearing, white pickling removes any oxide on the plate and leaves it ready for subsequent tinning.



stands on 14 ft. centers. Each stand is driven by a 200 hp., 316 volt d-c. motor. The first stand drive is of 600-1500 rpm., with a gear ratio of 7.0:1, giving a roll speed of 86-214 rpm., and a strip speed of 404-1010 ft. per min. The speed of the motor on the second stand is 550-1250 rpm., with a gear ratio of 5.26:1, giving a roll speed of 105-238 rpm., and a strip speed of 495-1120 ft. per min.

Tension rolls are driven by a motor duplicating that on the second stand, while the delivery reel has a motor duplicating that of the first mill stand. There are two 50 kw., 450-1200 rpm., 225 volt d-c. drag generators. Screwdowns on each stand are operated by two 15 hp., 230 volt d-c. motors. Roller bearings are used on the work rolls, the back-up rolls and the pinion stands of these mills, with ball bearings on the gear set. Forged steel work rolls are employed, with cast steel back-up rolls.

The single stand mill is an 18 in. and 49 in. x 48 in. mill driven by a 300 hp., 316 volt, 400-1000 rpm., d-c. motor. This mill is so arranged that it can also be used as a two-high mill for processing drum stock, by changing rolls, and moving the motor on skids provided for the purpose so as to cut out one gear reduction.

These mills will accommodate strip in widths of 16 in. to 36 in. Power consumption of the main drives is 17.2 kwh. per ton, and of auxiliary drives 8.4 kwh. per ton. Departmental capacity is 22,000 gross tons per month.

Temper mill drives receive d-c. power from five motor-generator units, each consisting of a 400 kw., 316 volt generator, a 100 kw., a 250 volt booster generator for the delivery reel, and a 25 kw., 250 volt exciter driven by an 800 hp., 6600 volt, 1200 rpm., synchronous motor.

TINPLATE FINISHING

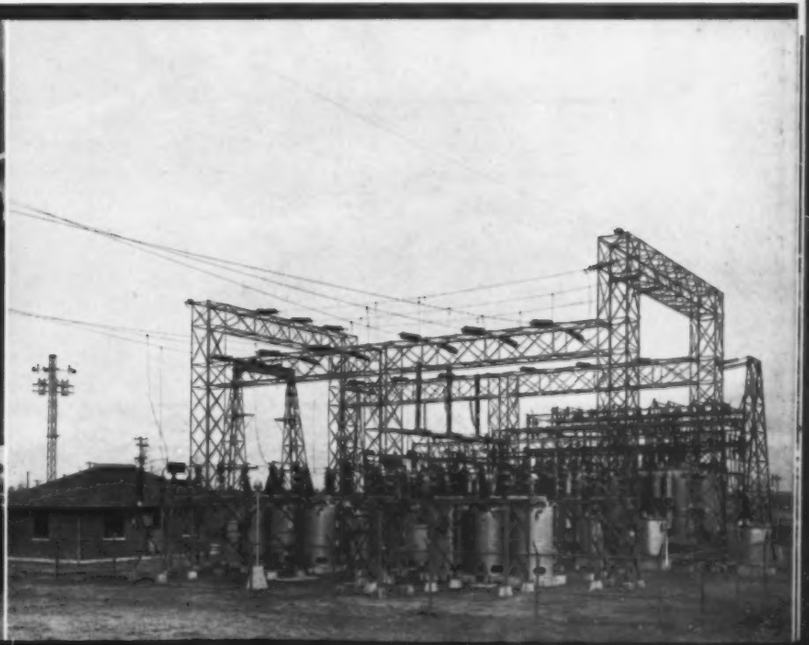
The coils next pass to the shearing lines, where they are side trimmed, cut to length, assorted and stacked. Eight shearing lines are provided, each consisting of an uncoiler, a rotary side trimmer, a flying shear, an assorter, and a stacker. These lines handle widths of 16-38 in., in gauges from No. 6 to No. 38, at speeds of 75-300 ft. per min., cutting lengths within the range of 12-40 in.

J. B. RICHARDS
Superintendent, Annealing Department

The assorter is an automatic device which measures the thickness of the sheet with a micrometer, throwing out under and over gauge sheets and allowing only

(Left) Twenty-eight tinning units, 64 in. and 75 in. in size, are installed, and are heated by natural gas in a premixing system.

(Below) A 70,000 kva. outdoor sub-station contains transformers with a double secondary winding, giving power at 44,000 and 6,600 volts.



sheets of proper gauge to pass through to the stacker.

The shearing units operate with variable voltage control, each unit having a 50 kw., 250 volt d-c. generator and a 3 kw. exciter driven by a 75 hp., 1150 rpm., 220 volt motor. Scrap from the shearing lines falls down through openings onto a conveyor below the floor and is carried to scrap bundlers at either end of the row of shearing units.

After shearing, the sheets are moved to the white picklers in lifts of 5 to 10 tons. Here sheets are placed on edge in pickling crates and the process is effected through two batch type picklers. Two acid tanks and one water tank, 6 ft. 10 in. square x 5 ft. deep, with a capacity of 1720 gallons each, are installed in line on each pickler. Temperature of the solution is automatically controlled. Overhead is an oval conveyor track upon which travel hangers to which pickling crates are attached. The section of track over the line of tanks may be lowered and raised on a rocker arm action so as to submerge and churn the loaded crates. Each crate progresses through the three tanks.

This operation removes any oxide that might have formed on the plate from exposure to the atmosphere. When removed from the wash tank, plate is immediately placed in boshes of steel plate construction, 5 ft. long x 2 ft. wide x 4 ft. deep, filled with water to which a little hydrochloric acid has been added. A number of these boshes, handled by specially built trucks, provide the necessary storage between the white pickling and the tinning operations.

Twenty-eight tinning units are installed, with 26 producing tin plate at about 1.15 gross tons per hour each, and 2 producing terne plate at about .9 gross ton per hour each. Eighteen of these are 64 in. two-way units, the other ten being 75 in. machines two or three way. Each unit is composed of a magnetic feeder, a roll-type feeder, a tinning machine, a catcher, washer, branner, and piler, with an overall length of 30 feet. The average coating of tin applied is about 1½ pounds per base box, or approximately 1½ per cent of the weight of the finished plate.

The tinpots are heated by natural gas in a pre-mix system. There are four pre-mixing units, each of 10,000 cu. ft. per hour capacity.

Two recleaning lines are also installed in this department.

LUBRICATION

Throughout the entire mill, the most modern types of automatic lubrication equipment has been provided. Circulating systems, complete with storage tanks, coolers, and pumps, all completely automatic, provide oil lubrication, while mechanical centralized grease sys-

TABLE 3—LUBRICATING DATA

OIL SYSTEMS

Number	Type of system	Storage capacity (gallons)	Rate of circulation (gallins per minute)	Kind of oil	Number of bearings served	Equipment lubricated
1	Circulating system	400	50	Heavy	6	Vertical edger gear reduction.
1	Self-contained circulating system	100	5	Heavy	6	Vertical edger mill bearings.
1	Circulating system	1,000	100	Heavy	12	Universal pinions, gears and bearings.
2	Circulating system	12,000	320	Heavy	28	Finishing mill back-up bearings.
1	Circulating system	3,000	100	Light	24	Generators and mill motors.
2	Circulating system	8,000	150	Heavy	40	Cold mill back-up bearings.
1	Circulating system	1,500	19	Medium	4	No. 5 Temper mill back-up bearings.

CENTRALIZED GREASE SYSTEMS

Number	Number of bearings served	Equipment lubricated
1	92	Universal mill bearings.
3	870	Finishing work rolls, tables, etc.
2	192	Coilers.
2	350	Cold reduction mill work roll bearings.
4	160	All bearings on tandem temper mills.
1	32	No. 5 temper mill excepting back-up rolls.

tems serve the various roller bearing applications. Details of the major lubrication systems are given in the accompanying Table 3.

POWER

The connected load of tinplate plant is as follows:

	kva.
Vertical edger	
1000 hp. x .746, 80 per cent power factor	930
Universal mill motor-generator set	
4900 hp. x .746, 80 per cent power factor	4550
Finishing train motor-generator sets	
2 x 8400 hp. x .746, 95 per cent power factor	13200
Spray pumps	
3 x 1250 x .746, 85 per cent power factor	3300
Auxiliary motor generator sets, hot mill	
3 x 1080 x .746, 58 per cent power factor	4160
Air compressor, hot mill	
500 x .746, 100 per cent power factor	373
Hot mill auxiliary transformers	4725
Cold reduction motor-generator sets	
2 x 7050 x .746, 95 per cent power factor	11080
Temper pass motor-generator sets	
5 x 800 x .746, 95 per cent power factor	3145
Auxiliary motor generator sets, cold mill	
2 x 1460 x .746, 90 per cent power factor	2420
Air compressors, cold mill	
2 x 500 x .746, 100 per cent power factor	746
Cold mill auxiliary transformers	4500
Total 6600 volt, connected load	53129

To meet this additional load, representing an increase of approximately 40 per cent of the previous connected capacity, additional facilities were supplied for transmission by the local power company. No additional generating equipment was installed in the steel plant.

The maximum generating capacity of the steel plant is 59,500 kw. The total 15 minute demand of the plant, including the new installation, has been estimated at 95,500 kw., leaving a demand on the utility company of 36,000 kv.

Added demand is taken care of through the extension of a 110,000 volt transmission line to the Fairfield Steel Works and the installation of a 70,000 kva., 110,000 volt transformer station. This station consists of four 23,333 kva. single phase transformers, one of which is a spare. The transformers have a double secondary winding, so designed as to give 46,666 kva. at a voltage of 44,000 and 23,333 kva. at a voltage of 6600. The latter power goes directly to the tin mill, while the former goes to the 44,000 volt substation of the steel plant.

Rotating electrical machinery in the hot and cold mills and finishing department total as follows:

	Number	Total hp.
Motors—hot mill	464	63,230
Generators—hot mill	34	27,677
Total hot mill	498	90,907
Motors—cold mill and finishing	765	48,290
Generators—cold mill and finishing	113	23,310
Total cold mill and finishing	878	71,600
Grand total	1376	162,507

Power consumption of the plant averages approximately as given below:

Hot mill	114 kwh. per ton
Cold reduction	106.7 kwh. per ton
Temper mills	25.6 kwh. per ton
Cleaning, shearing, finishing	59.6 kwh. per ton
	305.9 kwh. per ton

Other service requirements of the mill are as follows:

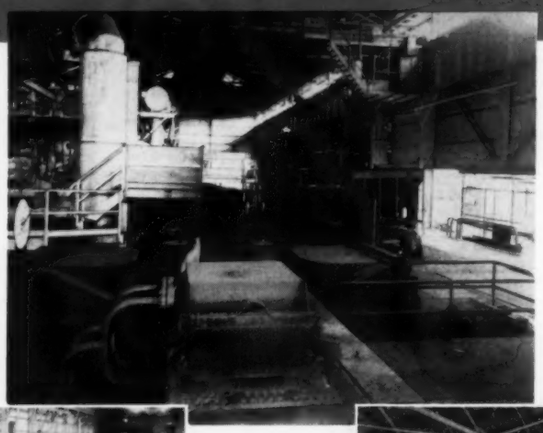
	Hot mill	Cold mills and finishing	Total
Steam, lb. per hour, maximum	7,500	82,500	90,000
Steam lb. per hour, average	4,000	46,000	50,000
Water, gallons per minute, maximum	8,500	2,000	10,500
Water, gallons per minute, average	4,800	900	5,700
Compressed air, cu. ft. per min., maximum	1,000	3,300	4,300
Compressed air, cu. ft. per min., average	600	2,230	2,830

As may be seen by this view of the tin plate office, buildings are convenient, well-designed and modern in every respect.

TIMKEN BEARINGS ARE USED IN IMPORTANT EQUIPMENT AT NEW SOUTHERN TIN PLATE MILL

TIMKEN BEARING EQUIPPED

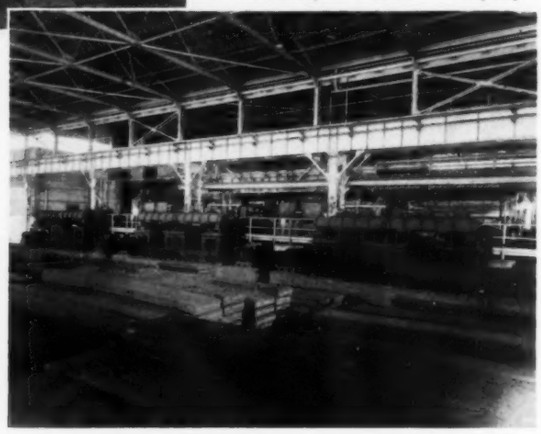
A symbol of quality for any piece of equipment with which it is associated



36" Timken Bearing Equipped Vertical Edger manufactured by Aetna-Standard Engineering Company.

Timken Bearing Equipped Hot Strip Uncoiler and Uncoiler Upender manufactured by E. W. Bliss Company.

Timken Bearing Equipped Furnace Pusher Drive manufactured by Youngstown Foundry & Machine Company.



The 36" vertical edger, hot strip uncoiler and uncoiler upender, furnace pusher drive and slab pusher installed in this new plant are equipped with TIMKEN Tapered Roller Bearings at the hard service points.

Modern steel mill practice includes the use of TIMKEN Bearings in all kinds of main and auxiliary equipment. TIMKEN Roll Neck Bearings hold the world's record for endurance in hot strip mills. You will find them also in rod mills, seamless tube mills, mill drives, pinion stands, approach tables and run-out tables, protecting vital moving parts against radial loads, thrust loads, shock and misalignment; simplifying lubrication; reducing power consumption; and keeping equipment running constantly.

You can't afford to take chances where bearing failure might tie-up the whole plant. Specify TIMKEN Bearings and take advantage of their proved dependability.

THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO

TIMKEN

TAPERED ROLLER BEARINGS

ADVERTISING PAGES REMOVED

Cleveland and Pittsburgh Sections

ASSOCIATION OF IRON AND STEEL ENGINEERS

YOUNGSTOWN, OHIO - - MAY 2, 1939

Inspection Trips

10:00 A. M.—Brier Hill Plant of Youngstown Sheet and Tube Company. Buses leave from Ohio Hotel.

Luncheon—12 noon. Ohio Hotel.

1:30—Inspection trip to new seamless tube mill, Campbell Works, Youngstown Sheet and Tube Mill. Buses leave from Ohio Hotel.

T. B. McELRAY, *Chairman*
Superintendent Electric Light & Power Dept.
Carnegie-Illinois Steel Corp., Youngstown, Ohio

Technical Session

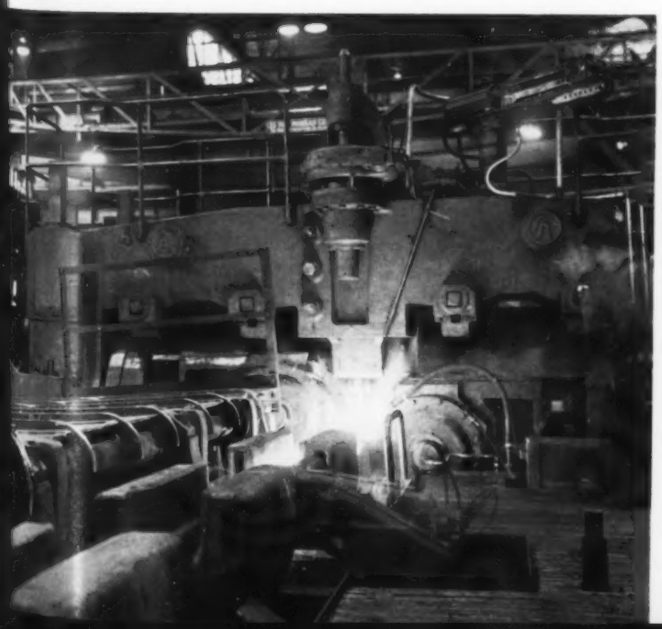
OHIO HOTEL . 8:00 P. M.

"Development and Latest Design of Seamless Tube Mills"—by Carl Olson, General Manager, Aetna-Standard Engineering Company.

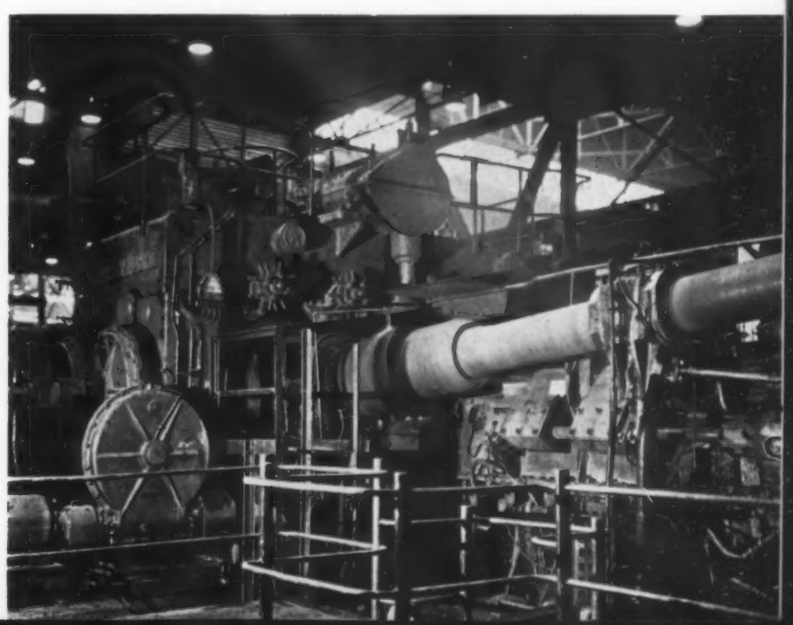
"Application of Anti-Friction Bearings to Seamless Tube Mills"—by S. M. Weckstein, Timken Roller Bearing Company, Canton, Ohio.

Dinner—6 P. M. Ohio Hotel.

This piercing mill is one of the new units in the seamless tube division of Youngstown Sheet and Tube Company, which will be seen on the inspection trip.



Rear view of one of the new piercing units, showing a drive spindle. Each unit is driven by a 5000 hp., 360 rpm. synchronous motor.



PERFORMANCE of BLOOMING MILL AUXILIARY DRIVES with WARD-LEONARD Control

By W. A. PERRY, Supt.
Electrical and Power Depts.
INLAND STEEL CO.

W. B. SNYDER
Industrial Dept.
GENERAL ELECTRIC CO.

Presented before the A. I. & S. E. Annual Convention, Cleveland, O., September 27, 28, 29, 30, 1938

▲ IN February, 1937 one of the authors described before the Association of Iron and Steel Engineers, the Ward Leonard controlled auxiliaries of the Inland Steel Company's 46 inch blooming mill.* This installation, which incorporates the screwdowns, sideguards, live tables, and slab shear is the first in which Ward Leonard control has been applied to all the major auxiliaries of a blooming or a slabbing mill.

When the original paper was presented, the drives had been in operation only a few months, and specific operating data were not available. Now, after about two years of service, a background of operating experience has been obtained, and tests to check the performance of the drives have been made. It is the purpose of this paper to describe the results obtained with these drives in actual operation, and to discuss the suitability of this type of apparatus for service on the heavy duty auxiliaries of blooming and slabbing mills.

METHOD OF OPERATION

Although these drives have been described previously, it may be well to review briefly the manner in which they operate. The basic method of control is shown in Figure 1. The shunt wound driving motor is supplied from a generator having three fields, one a separately excited shunt field, one a selfexcited shunt field, and one a heavy differential series field. The armatures of the motor and generator are connected solidly together. All control is accomplished by manipulation of the generator shunt fields.

The separately excited shunt field of the generator is the main controlling medium. A set of directional contactors in this field provides for starting, stopping or reversing the drive. A field weakening contactor and resistor provide a low speed point for jogging or inching.

A set of directional contactors in the selfexcited shunt field is provided to connect this field in "suicide" during deceleration, in order to offset partially the magnetizing effect of the differential series field on reverse current, thus increasing the decelerating torque. Discharge contactors and resistors are provided in both shunt field circuits.

Figure 2 shows the volt-ampere characteristics of the three-field generator. These curves also represent the speed-torque characteristics of the motor supplied by the generator, motor speed being proportional to armature voltage, and motor torque to armature current. Curve A shows the normal characteristic with both shunt fields of the generator excited. At no-load the generator develops a voltage of about twice normal, due to the combined effect of the separately and self excited shunt fields. As the load increases the generator excitation is decreased by the differential series field and by the weakening of the self excited shunt field, resulting in a drooping voltage characteristic. As the load increases further a point is finally reached where the generator voltage is decreased to a value sufficient only to overcome the IR drop of the circuit.

The broken lines in Figure 2 represent full load current and normal voltage on the motor supplied by the generator, and are equivalent to rated motor torque and speed. It will be observed that at no-load the motor will run at slightly over 200 per cent speed. Even at full load torque the motor speed is about twice normal. As the load increases to 200 per cent, the motor speed decreases to about the normal value. Finally, the motor will stall with the torque definitely limited to about 2½ times normal.

Curve B shows the characteristics obtained with the self excited field of the generator opened. This is, of

*See Page 30, Iron and Steel Engineer, May 1937.

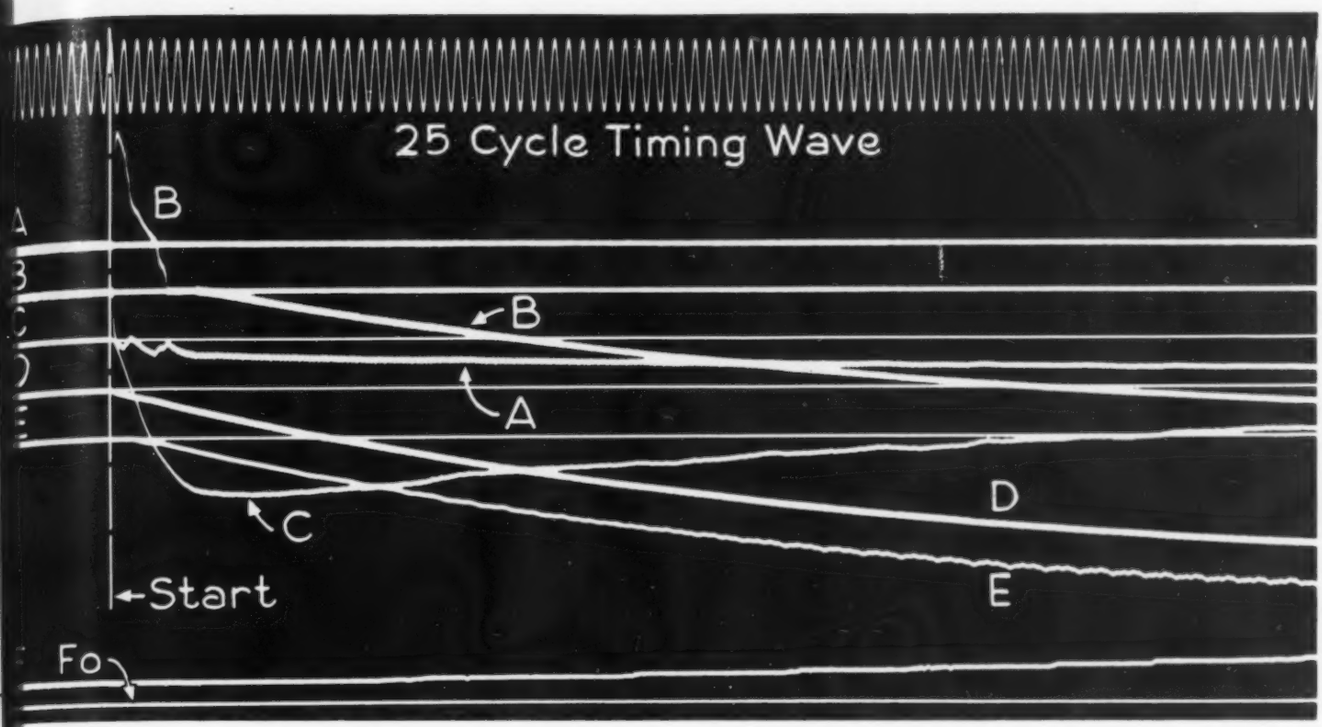


FIGURE 3—Above is shown an acceleration on the 46 inch mill screw-down, using Ward-Leonard control. A is a separately excited general field; B is a self-excited general field; C is the armature current, Motor A; D is the armature voltage, Motor A; E is the screwdown motor speed; and F the roll position.

course, the characteristic of an ordinary differentially compound wound generator. A comparison with curve A illustrates the marked effect of the self excited shunt

FIGURE 1—An independent control, such as shown below, is provided for each of the two generators supplying the screwdown motors. These are operated from a common master switch.

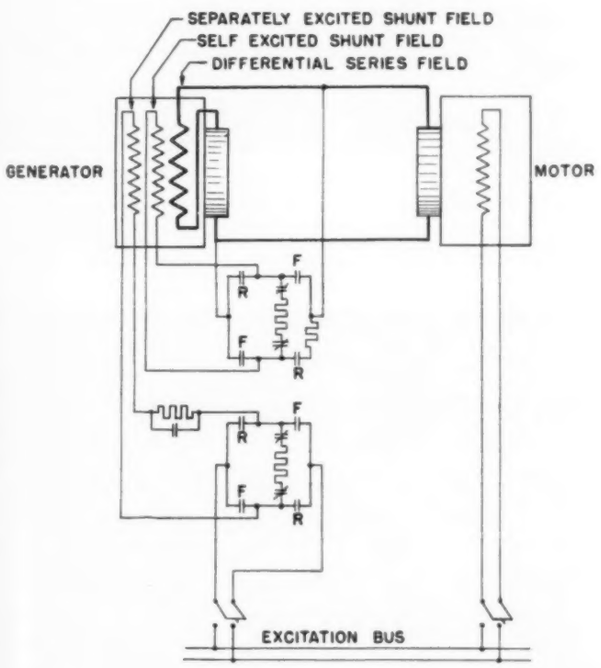
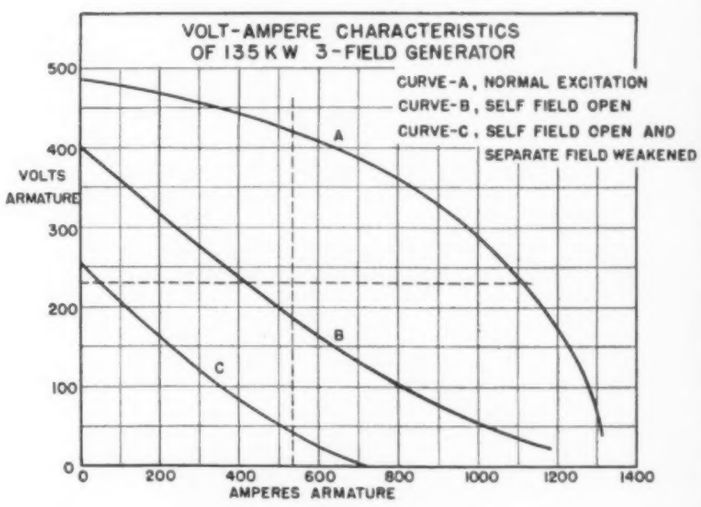


FIGURE 2—Below the volt-ampere characteristics of a 135 kw. three-field generator are illustrated. Curve A is the normal characteristics with both shunt fields of the generator excited. Curve B shows the characteristics obtained with the selfexcited field of the generator opened. Curve C is obtained by opening the self excited shunt field and weakening the separately excited shunt field. The broken lines represent full load current and normal voltage.



field in providing higher torque at any running speed.

Curve C shows the characteristic of these drives on the first point of the master switch, obtained by opening the self excited shunt field and weakening the separately excited shunt field.

ARRANGEMENT OF DRIVES

The screwdowns of the 46 inch mill are driven by two 150 hp., 450 rpm., 230 volt shunt wound motors, each supplied from an individual generator. Two independent controls, such as shown in Figure 1, are provided, one for each generator, and these are operated from a common master switch. The drive was originally equipped with two shunt brakes, but due to the effectiveness of regenerative braking these have been found unnecessary. Now only one brake is installed, used only to prevent the rolls from opening when an ingot enters.

The front and back tables, and the east and west side-guards, are each driven by two motors in series, each pair of motors being supplied from one generator. This, of course, produces a drive with a normal rating of 150 hp., 225 rpm. Each sideguard was originally provided with shunt brakes. but these have been found unnecessary, and have been rendered inoperative.

The slab shear is driven by two 275 hp., 435 rpm., 250 volt, shunt wound motors, each supplied from an individual generator, and provided with two independent controls operated from one master switch. Since the shear was originally designed to cut 6 inch slabs, and now cuts 40 inches by 9¼ inches slabs in regular production, a few modifications have been made in the basic control scheme. The separately excited shunt fields of the generators, and the shunt fields of the motors are heavily forced during the cutting stroke. To provide more rapid deceleration to slow speed, for accurate stopping, the self excited fields of the two generators are converted during deceleration to separately excited fields in opposition to the main fields.

TESTS

Tests have recently been conducted on the Ward Leonard drives by the use of a six element oscillograph with an additional timing vibrator. On each drive motor speed, armature current and voltage, generator self-and-separately-excited field currents, and time were recorded. In addition, travel was recorded on the screwdowns, side guards and shear. As a check on the performance of the Ward Leonard drives, tests were also conducted on the screwdowns of the 40 inch blooming mill. These screwdowns are driven by two 85 hp mill type motors with a modern form of series parallel constant potential rheostatic control.

A comparison of the tests on the 46 inch mill screwdowns with Ward Leonard control, and the 40 inch mill screwdowns with magnetic control discloses several interesting features. Both drives are adjusted for about the same maximum roll speed, 305 inches per minute on the 46 inch mill, and 290 inches per minute on the 40 inch mill. The maximum rate of acceleration on

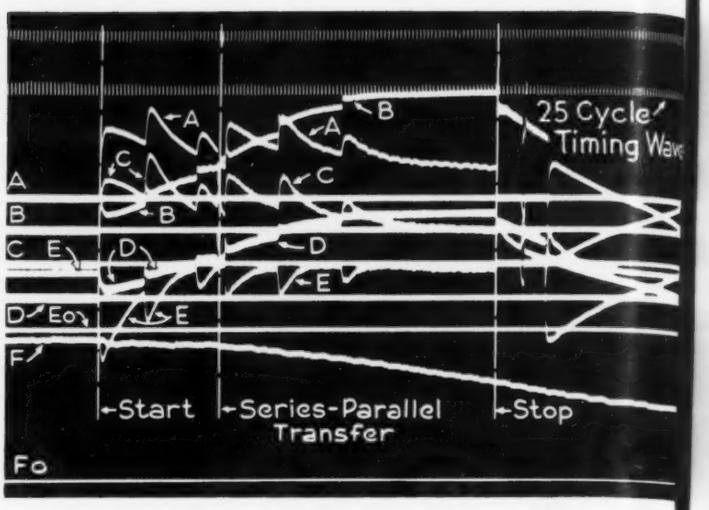


FIGURE 4—Acceleration on the 40-inch mill screws shows abrupt current and voltage changes on every control point.

FIGURE 5—Under stalled conditions, torque on the side guards builds up smoothly with Ward-Leonard control.

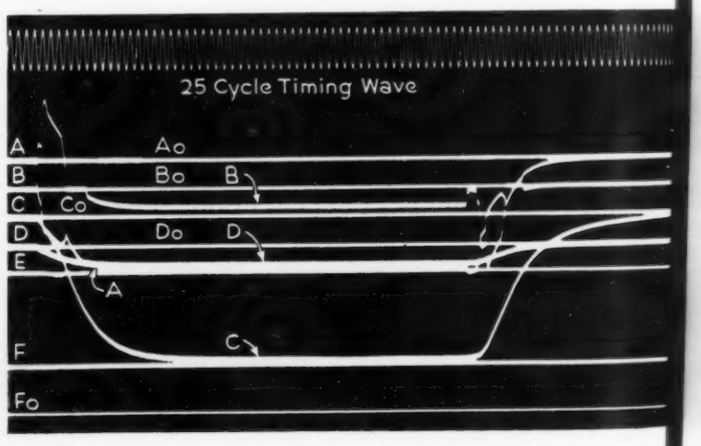
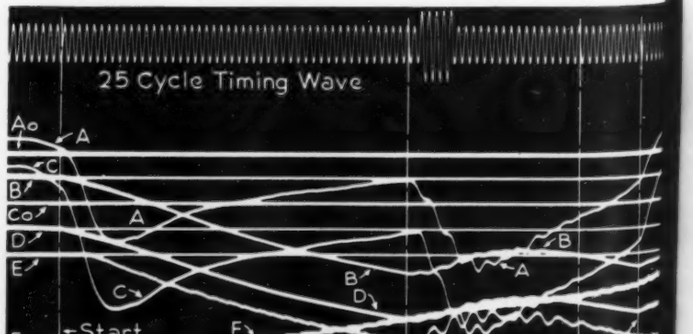


FIGURE 6—Typical record from shear drive when cutting a slab 36 inches by 8¼ inches.



both drives is approximately 10.7 fpm. per second Maximum roll opening is accomplished at the rate of approximately 4.1 inches per second on either drive, including accelerating and decelerating time.

The inertia of the 48 inch mill screwdowns is equivalent to that of a weight of 98,000,000 lb. at 305 inches per minute, and that of the 40 inch mill screwdowns is equivalent to 46,000,000 lb. at 290 inches per minute. The rated screwdown motor capacity is 300 hp. on the 48 inch mill, and 170 hp. on the 40 inch mill. Thus, in spite of the fact that the 46 inch mill screwdown motors are only 77 per cent larger than those of the 40 inch mill, they move a 113 per cent larger mass at 5 per cent higher speed. Furthermore, the 46 inch mill screwdown is "loafing" as its accelerating peaks are of the order of 120 per cent normal, and its decelerating peaks of the order of 150 per cent normal current. The 40 inch mill screwdown, on the other hand, is working at maximum capacity, with current peaks of 300 per cent occurring during each acceleration.

That this increase in performance is obtainable with the 46 in. mill screwdown without a corresponding increase in motor capacity and with considerably smaller percentage loads on the motors, is of course due to the difference in gear ratios. On the 46 in. mill the mill designers have taken advantage of the fact that under Ward Leonard control the mill type motor can develop twice rated horsepower at 200 per cent speed, by selecting gear ratios such that the WR^2 and friction load of the two drives, referred to their respective motor shafts, are almost identical.

While the maximum speed of the 40 inch mill screwdown is fixed by its gear ratio, the speed of the 46 inch mill screws can quickly be materially increased, if this should be desired, simply by reducing the values of resistance in the generator shunt field circuits. For example, during the tests the maximum speed of the 46 inch mill screws was raised first to 320 inches per minute, then to 365 inches per minute, and then back again to 305 inches per minute. The maximum accelerating rate on high speed operation was increased to 17 fpm. per second. These changes were accomplished in a total time of 15 minutes, including the time required for testing at each speed. Even at the highest speed the maximum current peaks observed were less than 220 per cent normal.

It is difficult to convey an adequate conception of the reduction in arcing and contactor noise by the use of Ward Leonard control. The oscillograph records partially illustrate the difference. Figure 3 shows an acceleration on the 46 inch mill screws. Here the armature current and voltage change very smoothly, all transient phenomena being confined to the generator field circuits. Figure 4 shows an acceleration on the 40 inch mill screws, with armature current and voltage changing abruptly on every point of the control. Figure 4 also illustrates another interesting feature. Compound wound mill motors are often preferred to shunt wound motors, because the compound wound motor produces greater torque per ampere. While this is true under steady state conditions, during transient conditions the transformer action between the shunt and series fields bucks down the shunt field excitation as the series field excitation is increased, in an endeavor to hold the motor flux constant. On Figure 4 the motor shunt field current can be seen decreasing with every increase of armature current, and actually reversing at the instant of starting. Thus, during acceleration, the average torque per ampere is probably very little greater than would be obtained with a shunt wound motor. If greater torque per ampere is needed, this can readily be obtained by momentarily forcing the field of a shunt motor.

The sideguard tests show a maximum speed of guard movement of 43 inches per second. Acceleration is never completed since the maximum travel does not permit the drive to come up to speed. Full travel is accomplished at a rate of approximately 29 inches per second, including starting and stopping time. The maximum rate of acceleration is approximately 27.5 inches per second per second.

The advantages of the three-field generator form of Ward Leonard control are most pronounced during stalling conditions on the sideguards. These drives have been adjusted for a stalled current of about 350 per cent, and the stalled input to the motors on one guard is approximately 124 kw. If the same torque were obtained with magnetic control, the power drawn from the line would have been 413 kw. Since the drive goes from running to stalling conditions automatically, with no control set-up changes whatever, there is no possibility of excess current flowing through the motors. On stalling, the torque builds up to the maximum value smoothly, as contrasted to the shock loading of a magnetically controlled sideguard. Figure 5 shows a record made during stalled conditions on the sideguards of the 46 inch mill.

The table drives on the 46 inch mill are also operated

Group assembled control in back to back arrangement, for Ward-Leonard operated auxiliaries.

at well under maximum duty. The free running surface speed of the table is approximately 450 fpm. When the drives were installed, provision was made to limit the table speed to a lower value, but this feature is not used. The tables accelerate from rest to 90 per cent of full speed in approximately 3 seconds, and plug from full speed to rest in approximately 1.5 seconds. The maximum current observed was about 100 per cent during acceleration, and 150 per cent during deceleration.

The shear drive was originally laid out to cut 6 inch slabs at the rate of eleven cuts per minute when running continuously. Actually it now cuts 30 inch by 6 inch slabs at the rate of fourteen cuts per minute, and 47 inch by 4½ inch slabs at the rate of fifteen cuts per minute, in cases where several crops are made at the end of one slab. Even when shearing a 36 inch by 8¼ inch slab (the largest available during the tests), cuts were made at the rate of ten cuts per minute, with an appreciable rest period between cuts. The peak currents observed during the tests were less than 275 per cent normal, and the average maximum of eight cuts on 36 inches by 8¼ inches was 235 per cent. These low values of current are attributable to rapid acceleration, which permits the drive to reach about 135 per cent speed before the cut, and to the current limiting characteristics of the generators, which permit the drive to slow down, giving up its stored energy as cutting effort during the cut.

A typical record of a cut on a 36 inch by 8¼ inch slab is shown on Figure 6.

PERFORMANCE

Two years of successful operation with performance as indicated by the tests show that the 3-field generator form of Ward Leonard control is capable of doing a highly satisfactory job on blooming mill auxiliaries. However, we all know that magnetic control also provides satisfactory operation. The motors and magnetic control for an installation of this type would cost about $60,000, and the equivalent motors, motor-generator sets, control, and switchgear for a Ward Leonard installation would cost about $120,000, both these figures being manufacturer's selling prices. So the question of why the user should pay more money for the Ward Leonard control still remains to be answered. A comparison of the features of the two types of control may assist us here.

Stopwatch timing of the operation of the 46 inch mill indicates the ability of the auxiliaries to save a few seconds on each movement, as compared with mills having magnetically controlled auxiliaries. For example, the manipulators will turn a piece on edge in 5 or 6 seconds, as compared to the usual 8 or 9 seconds. The tables will stop a piece and return it to the rolls in about 2 seconds, whereas 3 or 4 seconds is the usual figure. That these small savings represent a real increase in mill production is shown by the fact that the record tonnage of this mill is 280 gross tons of finished slabs in one hour. This is on slabs averaging 4½ inches thick, rolled from 18,000 lb. and 25,000 lb. ingots, the average weight being 20,600 lb.

This increase in speed of operation is, of course, not inherent in Ward Leonard control, as equivalent speeds could be obtained by magnetic control. However, for equivalent operating speeds, Ward Leonard control will function with less stress on the driving motors and mechanical parts, and less wear on the control devices. Or, for equivalent stresses on the apparatus, higher rates of acceleration and deceleration may be obtained with Ward Leonard control. The step by step application of voltage produced by magnetic control will give a lower average accelerating torque for the same peak currents than will the smooth application of voltage produced by Ward Leonard control.

With Ward Leonard control it is possible to take advantage of the ability of the mill type motor to operate successfully at double voltage, thus in effect doubling the horsepower of the drive, and permitting the selection of gear ratios better suited to rapid acceleration and deceleration. This is another factor in obtaining higher speed of operation with Ward Leonard control.

As a corollary of the last statement, it would appear that with Ward Leonard control smaller motors could be used than would be needed with magnetic control. Our tests give some indication that this is the case, particularly on the screwdown and table drives, although to date advantage has not been taken of this in any installation

While the speeds of magnetically controlled auxiliaries are fixed by their gear ratios, it is possible to vary the speeds of Ward Leonard controlled auxiliaries over a wide range by adjusting the generator field resistors. Higher accelerating and decelerating torques can be provided in the same fashion. In addition, greater torque can be produced by field forcing on the motors, without the disadvantage of slower speed, as the generator voltage can be raised to compensate for the lower basic motor speeds.

The three-field generator is inherently self-protecting, so that the maximum generator current and motor torque are definitely limited to predetermined values. Thus, in case the screws jam or the shear fails to cut a cold piece, the drive simply stalls. In such cases with the magnetic control the motors often arc over before the overload relays can open the line contactors, with consequent damage to commutators, brushes, and brush rigging, and burning of control contactors. Since a modern mill auxiliary motor with its commutator in good condition may draw eight or ten times normal current before it arcs over, the mechanical parts of the drive will be subjected to extremely high stresses, and costly breakage may result. This advantage of Ward Leonard control has been demonstrated quite conclusively on the 46 inch mill, especially in the earlier stages of operation, before the operators were entirely familiar with the apparatus. Several cases of faulty operation, which would undoubtedly have resulted in mechanical breakage had magnetic control been used, merely caused the drives to stall.

With Ward Leonard control the motor torque on starting builds up smoothly to the maximum value, allowing the back-lash in gearing to be taken out before the motor develops a very high value of torque. With magnetic control on the other hand, a very high starting torque is developed as soon as the motor contactors close, and any back-lash will produce high values of shock loading on gears and pinions. This feature of the Ward Leonard control will reduce the stress and wear

on the mechanical equipment. The difference between the two types of drives in this respect can easily be recognized by observing the quiet and smooth operation of the Ward Leonard auxiliaries as compared to the slam-bang of magnetic auxiliaries.

Since the motor currents are definitely limited, and the motors are largely relieved of shock load, motor maintenance costs are reduced. In case a short circuit should occur, the short circuit current is only the amount which can be produced by one small generator, as compared to the high value produced by a short circuit on a 250 volt mill bus.

Control maintenance is also greatly reduced with the use of Ward Leonard control. The 46 inch mill screw-down control panels have a total of 26 100-ampere contactors handling generator field currents of the order of 20 or 30 amperes. The contactors themselves are small and inexpensive to maintain, and, since they are operated well below their rating, there is little or no burning and only slight mechanical wear. If this mill had been equipped with series-parallel magnetic control, a total of 20 600-ampere contactors would have been needed, and these contactors would be handling peak currents of the order of 1500 amperes.

That these are actual and not hypothetical savings is shown by the fact that the cost of maintenance and repair on the 46 in. mill auxiliaries, including mechanical and electrical parts and labor, have been only $0.0231 per ton. On the 36 inch blooming mill, which was revamped some time before the 46 inch mill was installed, and for which all new auxiliary equipment with magnetic control was purchased, the cost of maintenance and repair are $0.0426 per ton, or almost twice as high as on the 46 inch mill.

The Ward Leonard auxiliaries dispense almost entirely with resistor losses, as the only resistors are of small capacity, located in the generator field circuits, and no armature resistors are used. Thus, the accelerating and decelerating losses inherent in all forms of rheostatic control are almost entirely eliminated, and the power consumption of the Ward Leonard drive is materially less than that of equivalent magnetically controlled drives. Furthermore, the Ward Leonard auxiliaries operate from the a-c distribution system through their motor-generator sets, and thus use lower cost power than the magnetic auxiliaries do.

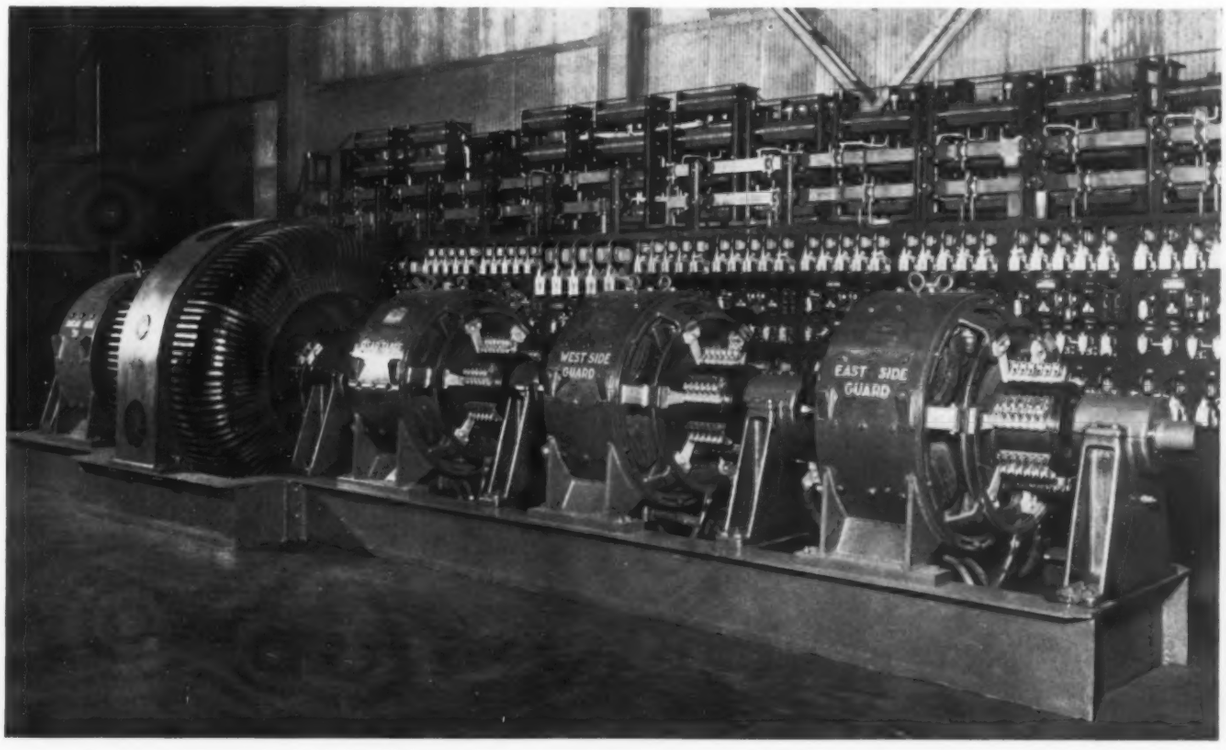
In addition to the direct power saving the lower resistor losses have another advantage. The present trend is to install auxiliary control in motor rooms, to protect it from the dust and dirt present in mill atmospheres. With Ward Leonard control it is possible to eliminate from the motor room the large resistors necessary with constant potential rheostatic control, which would materially increase the motor room temperature or would necessitate the installation of additional ventilating equipment.

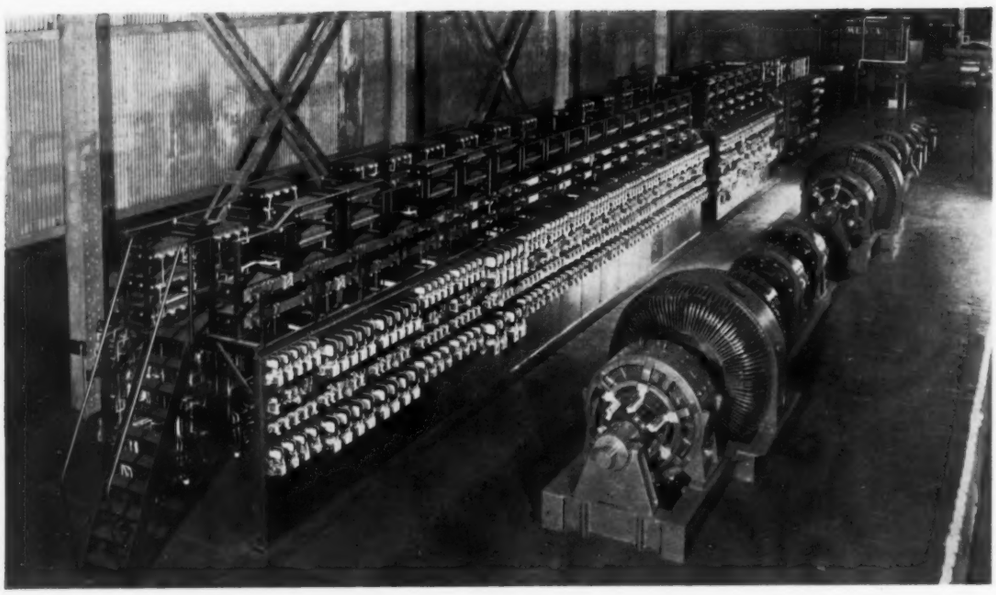
The 46 inch blooming mill auxiliaries consume 1.77 kw-hr. per ton at a cost of 4 mills per kw-hr., whereas similar magnetically controlled drives consume 2.4 kw-hr. per ton at a cost of 6 mills per kw-hr.

ECONOMIC JUSTIFICATION

From the above it appears that on an assumed production of 80,000 tons per month, which is well within the capacity of the 46 inch mill, the saving in mainte-

Duplicate motor-generator sets as illustrated below supply current for the auxiliaries under the Ward-Leonard system.





View of the motor showing the two motor generator sets for the Ward-Leonard controlled auxiliries.

nance and power costs of the auxiliaries will amount to about $26,600 per year, which would pay for the increased cost of the Ward Leonard auxiliaries in about 2¼ years. Possibly it is unfair to credit all this saving to the use of Ward Leonard control, as a good proportion is probably due to improved mechanical design. However, if only half is credited to Ward Leonard control, the increased cost will still be returned in 4½ years. This comparison neglects the intangible, but no less real advantages of the Ward Leonard system, such as ease of adjustment and increased mill production. It must be remembered that lower maintenance cost is always associated with fewer mill delays. The comparison also neglects the very important factor that the magnetically controlled auxiliaries should also bear their proportionate cost of a-c./d-c. conversion apparatus.

The 46 inch blooming mill is installed in line with and between the 76 inch and the 44 inch hot strip mills, and its 250 volt d-c. power system is interconnected with those of these mills. Before installation a survey of the 250 volt auxiliary power requirements for the 46 inch mill disclosed the necessity of additional conversion apparatus. If installed, this would have been a motor-generator set of at least 1000 kw. capacity, which with its switchgear would cost about $48,000. Further investigation showed that if the screwdowns, sideguards, front and back tables, and slab shear were segregated, sufficient 250 volt power was available from motor-generator sets already installed. This saving in motor-generator set capacity was a large factor in influencing the selection of Ward Leonard auxiliaries on the 46 inch mill, as concrete data on other savings were, of course, not available at that time. For a new installation, with an independent 250 volt power supply, the full cost of a 1000 kw. set should not be assessed against magnetic control for these six drives, but certainly at least half of this figure should be borne by the magnetic auxiliaries. On this basis the power and maintenance saving on the Ward Leonard auxiliaries would pay for their increased cost in about 2¾ years.

It is the conclusion of the authors that the use of Ward Leonard controlled auxiliaries on blooming and slabbing mills is entirely justified by both economic and operating considerations. This type of control has proved its ability to pay for the increased cost over magnetic control in from two to three years of normal operation and, in addition, has contributed materially to increased mill production. If the job were to be done over, and if at that time better means should not be available, we would do it again in the same way.

DISCUSSION

PRESENTED BY

F. O. SCHNURE, Electrical Superintendent, Bethlehem Steel Company, Sparrows Point, Maryland.

A. M. MAC CUTCHEON, Engineering Vice-President, Reliance Electric and Engineering Company, Cleveland, Ohio.

F. R. BURT, Metal Working Engineering Division, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

R. H. ELLIS, Electrical Engineer, United Engineering and Foundry Company, Pittsburgh, Pennsylvania.

I. N. TULL, Electrical Superintendent, Republic Steel Corporation, Cleveland, Ohio.

W. A. PERRY, Superintendent, Electrical and Power Department, Inland Steel Company, Indiana Harbor, Indiana.

C. J. PORTER, Electrical Engineer, Steel Company of Canada, Ltd., Hamilton, Canada.

R. G. WIDDOWS, Executive Vice-President, Electrical Controller and Manuafacturing Company, Cleveland, Ohio.

JAMES FARRINGTON, Electrical Superintendent, Wheeling Steel Corporation, Steubenville, Ohio.

F. O. SCHNURE: The authors have been very moderate in their claim of the economies experienced, particularly from the saving in mechanical maintenance. We have found that Ward-Leonard control will reduce the mechanical maintenance considerably, and this particular mill really hasn't run long enough for large mechanical repair jobs to be necessary. I would like to ask some of the mechanical-minded men to think this over and discuss it.

A. M. MACCUTCHEON: We all recognize that for many years we have had Ward-Leonard control. We weren't quite so clearly able to recognize the advantages and we weren't able to visualize all of the economies of the use of such means. There are certain fields in the application of motors where the Ward-Leonard has been used quite consistently, such as the paper mill field. In other words, we recognize that a very difficult job might be done successfully by Ward-Leonard when it was not possible to do it successfully in any other way.

I think there is an interesting point in connection with this application of Ward-Leonard control. Most often in the past Ward-Leonard has been used because of speed considerations and the control of speed. I think we recognize that Ward-Leonard is basically making the fullest use of the electrical equipment provided. It is most basically a constant torque drive, whereas in this application the requirement is quite different from constant torque. As the speed decreases an increasing torque is desired, with the further requirement that the maximum torque shall be limited, and certainly it is very cleverly accomplished in this drive.

I would like to take just a moment to consider with you a method of thinking of what determines the speed of a motor. The question has been asked so many times in the past, "Why cannot we do with a-c. motors, particularly in regard to speed control, what can be done with d-c. motors?" There is no question but that very successful speed adjustments may be made in a-c. motors. I have found in talking with some of the engineers with whom I have exchanged ideas a slightly modified way of expressing the determination of the speed of the motor, a little different approach which has seemed to help me and seemed to help them in considering a-c. or d-c. motors during a change in speed. There is a possibility it may be of assistance to you.

First and most primarily, we recognize that nature loves a balance. In fact that is the only thing that nature will tolerate. From that viewpoint, I say that the speed of any motor—and I think my statement is entirely genuine in its application—depends most primarily on two things. Now, of course, those two things are affected by other things, but just stating those two things, the speed of any motor, a-c. or d-c., depends upon the torque that is being produced and the torque that is demanded. If the torque being produced is greater than the torque demanded the motor will accelerate because it is out of balance. If the torque being produced is less than the torque demanded the motor will decelerate in order to produce the balance. When the torque produced is exactly equal to the torque demanded there will be a condition of constant speed.

In order to apply that thought more directly to classes of motors, I would like to introduce a new term. I nave not seen it used elsewhere. I want to introduce the term "basic speed" and I mean by basic speed that speed at which there is no torque produced. That speed can never be reached in any particular motor. It can only be approached. But I think that term is general in its application to either a-c. or d-c. or any type of motor—"basic speed."

In an induction motor that means the synchronous speed. We do not have synchronous speed induction motors, but if there were one there would be no torque produced because there would be no current flowing, which is an element of torque.

Now, going back to the question of how speed changes can best and most economically be secured, I think we can express it this way: If economically, easily, and by readily controllable means, you can change the basic speed of a motor, you can get adjustable speed.

Now, in the Ward-Leonard control, the basic speed is very readily changed, and in any Ward-Leonard control, I believe, that is correct.

Now, if I could find any point of slight departure in thought, it lies along the line of cost. In this particular application, I wouldn't think of throwing any doubt into the very complete analysis and presentation of cost figures, but rather in regard to applications in general. It is quite surprising when a particular application is thoroughly studied, particularly if it is a constant torque application. to find that the Ward-Leonard may actually be no more expensive. In order to achieve this result, it is necessary to take advantage of every permissible economy which doesn't sacrifice proper operation.

I would suggest particularly the matter of control and economy. Some years ago Ward-Leonard drives were furnished with control which introduced much the same control protection that had been used on field weakening or armature resistor accelerating motors. The source of power is relatively limited in a Ward-Leonard control, as compared with the same size motor being thrown on a large system, and consequently may not require the same degree or kind of protective features.

We have conducted a rather interesting experiment showing that there is no difficulty in commutation at all in throwing a 25 horsepower motor on a generator that is suitable for supplying the power to that motor. Actually it was not necessary, even at 230 volts, to introduce any resistance to successfully throw the motor right on the generator, because the transient condition is so much affected by the constants of the generator, as much as the motor.

I think that hasn't always been recognized, and I think there are other things in regard to control of Ward-Leonard control that have not always been recognized but that permit of economies in control. If all the economies are used, I can testify that there are certain Ward-Leonard drives not as large as the type of drive so ably described in the paper, but that actually do not have a first cost more than the type of drive that was used in the past, although the comparison has generally been with field-weakening motors, where advantage could be taken of the naturally

constant torque characteristic of the Ward-Leonard to reduce the size of motor, and yet provide ample torque. The excess torque available in the field weakening motor would not be necessary at the low speed, and under those conditions there are drives that are actually just as economical.

In closing, in thinking of the theoretical control of speed and torque, and of course of control of torque related to speed, as has been so clearly introduced in this drive by means of the peculiar field arrangement, in the d-c. motors the flux is a component of the speed and it also is a component of the torque. You have the flux under control very readily, very economically in the generator, and I will go even further and say you also have the ability to control it very readily in the motor, which doesn't happen to have been done in this particular installation because the purpose was not best served, but a combination of Ward-Leonard and field control works very effectively where wide speed ranges are desired, up in the range of 50 and 60 to 1. Then a combination of Ward-Leonard and field control, making certain of the torque demands of the application, can very effectively be used.

F. R. BURT: Although two installations of variable voltage reversing mill auxiliaries using three-field generators are now in successful operation in this country, this paper presents the first operating data which has been published, and it is therefore of more than ordinary interest.

On very few modern reversing mills does the time of reversal of the main motor limit the output of the mill. Usually the limiting factor is the speed of the tables, manipulators or screwdown, or a combination of the three. The flexibility of a variable voltage drive as described is such that not only can maximum speeds and accelerating rates be adjusted, but the shape of the speed-torque curve itself can be changed, by simply changing resistance values in the various field circuits. Thus the condition which is slowing up production can often be corrected.

At times the operating conditions of mills are changed, or different products rolled, which would make a change in the characteristics of the auxiliaries desirable, if it could be obtained. If magnetic control had been used on the Inland shear the increase of 60 per cent in slab thickness, as described by the authors, would have been a very serious matter and would probably have required a new drive. However, the new requirement was met by a relatively simple revision in the handling of the field circuits.

Since most of the active life of an auxiliary motor is spent in either acceleration or deceleration, the use of rheostatic control means an almost constant resistor loss of considerable proportions. It is recognized that variable voltage control should effect a material saving in power cost, but the amount is difficult to calculate. It appears that operating figures show an overall saving of 25 to 30 per cent in kw-hrs. per ton for the variable voltage drive.

European practice on similar applications favors the use of generators with separately excited and series differential fields only, the self-excited fields being omitted. This no doubt would simplify the control and the machines to some extent. Assuming the same no load and stalling points as with the three field machines, the volt-ampere curve, which can be considered as being the speed-torque curve of the motor, would approximate a straight line. In other words the volts, and hence the motor speed, would be inversely proportional to load. The effect of the self-excited field is to "blow out" this curve so the motor speed is maintained until a high value of torque is reached. This is a desirable feature since a motor supplied from a typical 3 field generator is capable of 50 to 60 per cent more torque at 230 volt speed than if supplied from a two winding generator having the same no-load and stalling points.

With an installation which will pay its way in 2½ to 4 years and which will thereafter show savings of 30 per cent in power costs and 45 per cent in maintenance, with less time lost in delays, greater flexibility, higher overall speeds, and less wear and tear on mechanical equipment, there is really no reason for anyone in the future to consider anything but variable voltage control for the main auxiliaries of blooming and slabbing mills.

R. H. ELLIS: When a paper on this subject was presented in Youngstown, sometime ago, I raised the question of the justification of the added cost. Now, from an electrical point of view, we are perhaps satisfied that it is justifiable because of the smoothness of control and the reduced upkeep of electrical equipment, but still, when a customer comes to us and says, "Can you justify fifty percent increase in cost?" we are in a position which necessitates recommending against the use of this method except on very large units.

The point about less breakage through the installing of the equipment is correct on all but one unit, and that is the manipulator side guards. The shock on the manipulator side guards is a shock which takes place after the unit is up to speed, and therefore, the shock is just as severe on the Ward-Leonard control as it is on resistor control, because the current to the generator does not reduce until after the shock has taken place. Therefore, mechanically we must still build as big and as strong a manipulator as we have built in the past.

Now, there are a few tonnage figures in here whose importance is questionable. The size of slab which is rolled has a lot to do with the tonnage figures. There is a mill in Cleveland, driven by a steam engine, and equipped with a hydraulic manipulator and resistor screwdown that will roll 214 tons an hour for a period of three hours. The figure given in the paper was 281 tons for one hour. There is not a lot of difference in the figures, so we cannot justify the Ward-Leonard control purely on this comparison of tonnage.

Don't misunderstand me, as an electrical man, I am not opposed to Ward-Leonard control. Admittedly, it is the line of least resistance. It doesn't take less space. Frankly, it probably takes as much space in the motor room as the resistance starter. The heat from the resistors is somewhat of a disadvantage but is such a small percentage of the motor room heat that I don't think it matters.

The size of the panels you have seen in the picture, is about 13 feet on two sides; meaning that there is a

total space of 26 feet available for resistance starters, which is sufficient.

The upkeep on the contactors is going to be less; there is no doubt about this, but this upkeep does not amount to a great deal of money.

However, the information we have received here is going to give us some food for thought and we certainly ought to thank the authors for submitting these figures to us so we can study them. Surely, it is up to us to know what the answer is, and be able to give it to the management.

I. N. TULL: The authors have left very little to be said about the performance of the equipment and its ability to do a hard job easily. That is, I think, one of the very outstanding characteristics of the Ward-Leonard system. Its fundamentals lend themselves to many modifications to fit the varying requirements of the industry, and I know of no better way in which this can be appreciated than to compare visually and audibly this modern blooming mill adaptation to an old magnetic system on a similar job.

It hasn't been many years since the mechanical design, principally gearing, had to be modified on tables, screwdowns, manipulators and shears in order to enable standard motors and control, generally selected on a basis of full running speeds, rather than on the acceleration requirements, to function anyway at all. The expense of keeping in service some of these older drives would have many times paid for the acknowledged higher first cost of the Ward-Leonard system.

Sometimes it has been a tough proposition to sell the management on an apparent excessive first cost, but a few more jobs like this bloomer job, and they'll be asking us to get such things for them.

We haven't a Ward-Leonardized set of auxiliaries, but we have operated main drives, main hoists, normalizer tables, shovels, etc., and have now had a year's run of the first wide strip mill hot runout tables and coilers to review and compare with the orthodox way these jobs have heretofore been done, and our experience parallels the experience indicated in this paper.

W. A. PERRY: Judging from the discussion, I don't believe there is much left to be answered. It was asked about the difference in the cost of power. In one case we charge alternating-current direct to the motor-generator sets for the Ward Leonard equipment, and in the other case, we charge direct-current from the direct-current part of the system, for the rheostatic control job.

We feel that the paper has been well received. We expected that it would take quite some time before we obtained enough actual figures to really show that the installation was justified. However, the mechanical men in the mill are more sold on it than are the electrical men at the present time. The mechanical department's work has been cut down considerably over like mills with rheostatic drives.

C. J. PORTER: The auxiliaries on our mill were installed with constant voltage magnetic control.

In studying our mill requirements, we concluded that the mill, being located in Canada with a limited market, would not be pushed to capacity for many more years to come. This factor carried sufficient weight to persuade us to hold to the cheaper first-cost magnetic control.

We determined the difference in the first cost between the two types of auxiliary control to be from $35,000 to $45,000. Our mill has been in operation a matter of a few months, and not sufficiently long to determine whether mechanical maintenance is going to be heavy or otherwise.

Our mill apparently is operating very, very smoothly, and comparing its operation with the Inland mill, it is difficult to see where one is definitely superior to the other.

We are at the present time studying the matter of a universal slabbing mill. The maximum roll opening for this mill, I understand, is to be 15 inches. Screwdown travel will be slight. If this mill is installed there will, no doubt, be edging mills on both the entry and delivery side, and side guard motion, it seems to us, will not amount to a great deal. Careful study on our part will be necessary before deciding whether we should spend extra money in considerable amount for Ward-Leonard control of auxiliaries or not.

It seems to me that the type of mills to be installed and the work they are going to be required to do are going to be deciding factors as to what type of auxiliary control we are going to employ.

R. G. WIDDOWS: Mr. MacCutcheon pointed out that nature is always trying to establish a balance. I think that point can well be applied to the question of magnetic control or Ward-Leonard control. The point of a greater upkeep cost of the magnetic control with contactors as compared with the Ward-Leonard control has been made. Nature is already on its way to even up that balance by the designing of better contactors than we have had in the past. Contactors are now built that will handle large currents with very low maintenance and very long life on the contact tips. I think this question can only be answered when two mills that are very similarly designed, one using Ward-Leonard system and the other using magnetic control, have been compared.

Mr. Ellis brought out the point that on some of these drives the mechanical strains set up are not due to the acceleration torque of the motor but due to actual strains set up after the motors have come up to speed and pointed out that the side guards are one drive where the stresses that are set up due to impact of the side guards closing in on the ingot or coming together on each other, are very much greater than any stresses set up during acceleration.

I am wondering if the same point should not also be applied to the screw-down drive. When the ingot hits the rolls it seems to me that shock to the screws and reflected back through the gearing is of greater magnitude than you would get due to the difference in accelerating peaks in the two systems under discussion. Possibly this applies also to the slab shear, as when the cut is made the stresses on the gearing and shaft would be greater than set up during the acceleration. I don't think that magnetic control is out of the picture by any means.

JAMES FARRINGTON: We are contemplating the installation of a galvanizer and conveyors and from the figures submitted to us—using a 32 kilowatt generator—with a speed range of 6 to 1, the Ward-Leonard system is going to be cheaper than the rheostat control.

REPUBLIC STEEL CORPORATION

Gulfsteel Division

ALABAMA CITY, ALABAMA

By T. J. ESS

▲ THE history of the Gulfsteel District of Republic Steel Corporation dates back something more than twenty-five years to one of the many attempts to firmly establish the iron and steel industry in the South. In spite of the prolific supply in this section of Alabama of the materials required for the manufacture of iron and steel, many of the early ventures into this industry ended unfortunately. The original nucleus of the present Republic unit was one of these ill-starred efforts, the Southern Iron and Steel Company at Alabama City, 56 miles northeast of Birmingham. This property was subsequently acquired by a new organization, the Gulf States Steel Company, which, with progressive management, thrived and grew, developing into a well-rounded, fully integrated steel producer.

In 1937, the entire properties of Gulf States Steel Company were acquired by Republic Steel Corporation, bringing the advantages of a wider sales organization as well as making available added raw material reserves already owned by Republic in the Birmingham district. Under Republic management, the plant has been further

The single blast furnace is normally blown hard at a constant rate, with the open hearths using the hot iron in varying percentage.

expanded and modernized, and has enjoyed good operations. Indications are that production facilities of this plant will be further enlarged in the future.

The general arrangement of the plant, as may be noted from the accompanying lay-out, is such that material follows a smooth, uninterrupted course through the manufacturing process, with a minimum of handling and railroad shifting.

COKE OVENS AND BLAST FURNACE

Coke producing facilities comprise one battery of 37 cross-regenerative ovens, 37 feet long by 9 feet 10 inches high, with an average width of 18¼ inches, each holding a coal charge of 12¼ tons. Nominal coking time is between 15 and 16 hours, giving a daily coke production of about 525 tons.

Coal comes largely from the company's Sayreton mine in the Birmingham district, with a washed analysis averaging as follows:

Fixed carbon	61.03 per cent
Volatile matter	29.10 per cent
Ash	9.87 per cent
	100.00 per cent
Water	5.60 per cent
Sulphur	.88 per cent

Coal is received in railroad cars which are unloaded through track hoppers into a conventional conveyor system. A Bradford breaker and a hammer mill reduce coal to the desired sizes. Charging equipment includes the usual storage bin and charging lorry, while coke is pushed, quenched, handled and screened in the usual way. By-product and benzol equipment is of the standard design.

Coke yield averages 72 per cent furnace coke and 5 per cent coke breeze. Gas make is about 11,000 cu. ft. per ton of coal coked, with about 40 per cent used for heating the ovens and the balance in heating operations in the steel plant. A 500,000 cu. ft. gas holder is provided in the coke gas system. Other by-products include 8½ gallons of tar, 3 gallons of light oils, and 25 lb. of ammonium sulphate per ton of coal, all of which are sold.

The single blast furnace is a stack with the following dimensions:

Hearth diameter	16 ft.
Bosh diameter	21 ft. 6 in.
Stockline diameter	17 ft.
Big bell diameter	9 ft. 6 in.
Height of hearth section	8 ft.
Height of sloping bosh section	13 ft.
Height of straight bosh section	8 ft.

E. I. EVANS
District Manager

A. G. DELANY
Assistant District Manager

Height of inwall section	54 ft. 1 in.
Height of sloping stockline section	7 ft. 5 in.
Total furnace height	90 ft. 6 in.
Height, hearth to center line of iron notch	10 in.
Height, hearth to center line of cinder notch	3 ft. 5½ in.
Height, hearth to center line of tuyeres	6 ft. 6 in.
Inwall batter	.49 in. per ft.
Bosh angle	78 deg. 12 min.

The furnace is supported on 8 columns. Twelve tuyeres are spaced around the hearth, and connected into a 33 inch diameter bustle pipe. Water cooling is carried up about 31 feet into the furnace shaft above the mantle. The top section of the furnace is metal-lined for a distance of 21 feet down from the top.

Furnace materials are received in railroad cars, and are unloaded into storage bins located beneath two elevated unloading trestles. A weighing lorry car conveys ore and stone to the skip hoist, while coke is discharged directly from bins to skip. Skip buckets dis-

charge into the furnace through a revolving distributor top.

Ore used in the furnace is of two types, the hard red ore, running about 31 per cent iron, and the brown ore, with 50 per cent iron. The former is extracted from slope mines, while the latter is obtained by a stripping operation. The hard red ore is practically self-fluxing. Limestone comes from the company's quarries in the district.

The furnace is blown by either of two turbo-blowers, designed for a maximum capacity of 60,000 cu. ft. per minute against a pressure of 30 lb. per sq. inch, and driven by a 7000 hp., 3050 maximum rpm. turbine operating with 375 lb. pressure, 250 degree superheat steam. The blowers are located in the powerhouse which is subsequently described in this article. Blast volumes usually range 40,000 to 45,000 cu. ft. per minute.

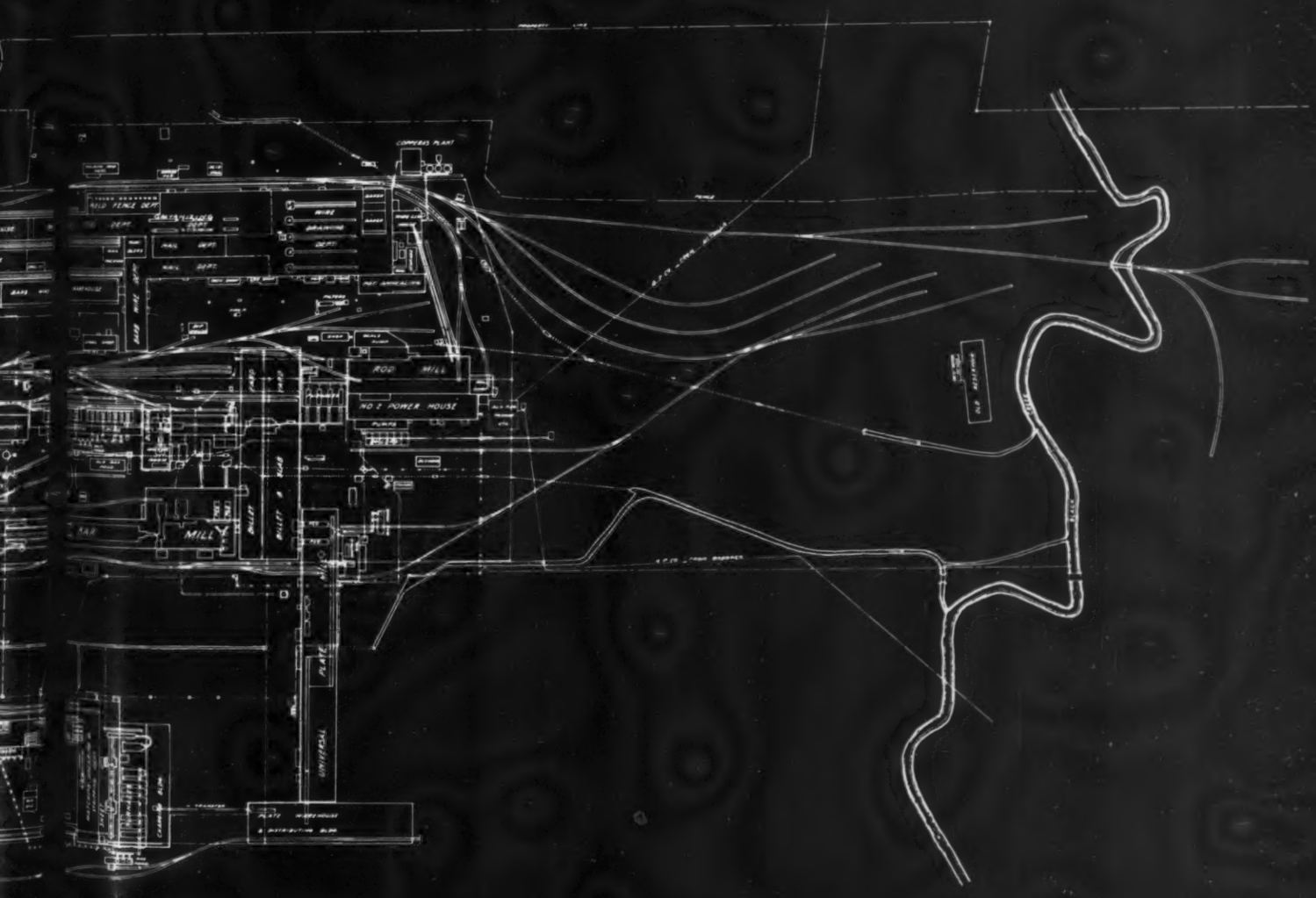
The blast is heated in four stoves 90 feet high by 20 feet diameter, each with 29,000 sq. ft. of heating surface. Blast temperatures average about 925 degrees F., with pressures of about 22 lb. per sq. in.

Gases leaving the furnace at temperatures averaging 350 degrees F. are carried off through two 60 inch up-

REPUBLIC STEEL CORPORATION

Gulfsteel Division

ALABAMA CITY, ALABAMA



takes, which converge into a single down-comer leading to the dust-catcher. Following this is a cleaner in which the path of gas flow is changed by baffles upon which water may be sprayed. Water lying in the bottom serves to trap much dust thrown out by the rapid directional changes of the gas stream. Cleaning is thus carried out to about one grain of dust per cu. ft. of gas.

The blast furnace is normally blown hard at a constant rate, with the open hearths using the hot iron by varying its percentage in their charge. A pig casting machine is also provided for use when necessary. Hot metal is transported in 125-ton mixer-type ladles.

OPEN HEARTH

This department consists of eight furnaces with a monthly capacity of about 50,000 tons of ingots. Five furnaces are rated at 90 tons, with hearths 32 feet by 12 feet 6 inches, one at 125 tons, with a 36 feet by 13 feet hearth, and two at 150 tons, with 48 feet by 15 feet hearths. The last two furnaces were installed only recently, in connection with Republic's expansion program in this plant.

All furnaces use a 12 inch roof with 15 inch ribs, and have sloping backwalls. Fuel is mainly natural gas, with some coke oven gas if available, and is introduced through pipe burners in the end walls of the furnace. Combustion air is supplied from a fan for each furnace. Each furnace also has a signal for furnace reversal, operated from differential checker temperature. The two new furnaces also have automatic furnace pressure control. Insulation has been carried out below the charging floor, and to some degree on port ends and side walls.

The varied type of products of this plant calls for a very wide range of open hearth practice. Steels, rimming, semi-killed and killed, are produced throughout the entire carbon range from .02 to 1.00 per cent, with some hot-topped product. The open hearth charge varies widely, depending on the available hot metal from the single blast furnace. With but few open hearth furnaces operating, the iron may form up to 75 or 80 per cent of the total metallic charge, while with a heavy pig iron demand, the percentage is reduced to perhaps 50 per cent. The great part of the steel produced is poured into ingots 20 inches by 22 inches, 21¾ inches square, 22 inches by 48 inches and 18 inches by 34 inches.

The modernization program also included a new 7½ ton floor charging machine, a 75 ton hot metal crane over the charging floor, a 210 ton ladle crane, as well as new ladle and slag car equipment. The open hearth ladles, of 150 tons capacity, have a double stopper rig for the simultaneous pouring of two ingots, while the slag ladles are of 370 cu. ft. capacity.

Dolomite for open hearth use is mined in the district. A rotary kiln, 8 feet in diameter by 125 feet long has been provided in the plant for calcining the raw dolomite.

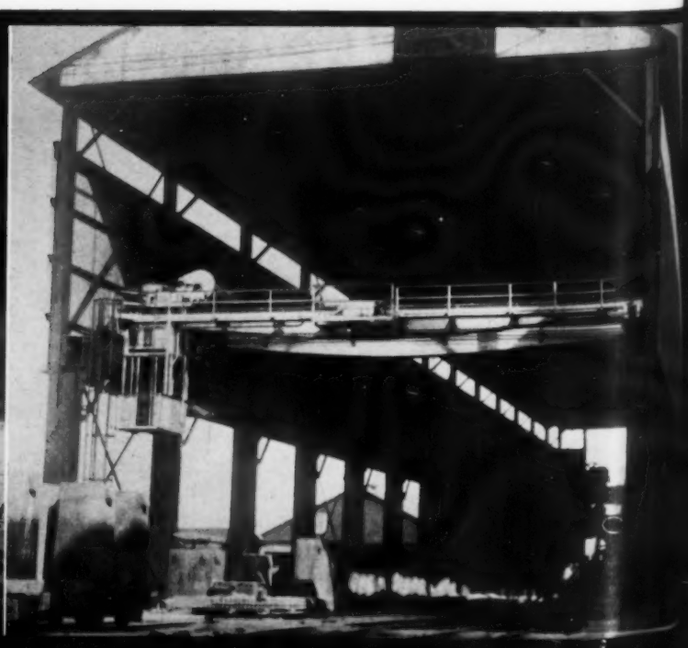
BLOOMING MILL

After pouring has been finished, the drag of ingots is moved into a recently completed stripper and mold building, which is 55 feet wide by 312 feet long, and parallels the open hearth building along the pit side. After stripping, the drag is moved to the soaking pits. There are six blocks of reversing regenerative pits, of four holes each. Four blocks are 5 feet by 7 feet 8 inches by 7 feet deep, holding two to six ingots per hole, while two blocks are 5 feet 4 inches by 14 feet by 7 feet deep, each holding four to ten ingots. All pits are equipped with automatic furnace pressure controls, and are fired with natural gas.

Ingots are drawn and carried to the mill approach table by overhead pit crane, and pass on to the blooming mill over a heavy duty mill table. The blooming mill is a 40 inch reversing unit driven by a 7000 hp., 50-120 rpm., 700 volt d-c. motor rated at 2,200,000 ft. lb. from 47 rpm. The motor-generator set is a dual unit, with two 3000 kw., 700 volt d-c. generators and a 5000 hp., 6600 volt, 352 rpm. induction motor, with automatic slip regulator and separate exciter set.

Open hearth ladles, of 150 tons capacity, are equipped with a double stopper rig for simultaneous pouring of two ingots.

A new stripper and mold building, 55 feet wide by 312 feet long, parallels the open hearth building on the pit side.



Blooming mill rolls, with a body length of 92 inches, run in composition water-lubricated bearings. Mill tables operate on roller bearings. All mill auxiliaries are motor driven, with magnetic control. A heavy shear, designed for slabs up to 40 inches wide by 8½ inches thick, serves to shear the varied size range from this mill. Sizes leaving the mill range from 3⅞ inch squares up to slabs 8 inches by 40 inches.

From the shear, a runout table conveys slabs and billets to a large storage yard running at right angles to the mill building. The other rolling mills are so laid out that their furnaces are adjacent to this storage space, thus reducing handling and giving a smooth material flow through the plant.

PLATE MILL

The plate mill is provided with two continuous end-charged, side-discharged, heating furnaces. The charging ends of these furnaces project back into the slab storage yard. Pusher mechanisms effect the discharge of the heated slabs on to a transfer table connecting to the mill approach table. The furnaces have hearths 12 feet wide by 57 feet 6 inches long, and are over-fired by natural gas through six high-pressure inspirating burners.

The mill is a 90-inch single stand three-high universal plate mill, using 32-inch diameter top and bottom rolls, with a middle roll 22 inches in diameter, all running in water-lubricated composition bearings. The mill is driven by a 4000 hp., 80-160 rpm., 800 volt d-c. motor which develops 720,000 feet lb. torque up to 80 rpm. The motor draws power from a motor-generator set consisting of two 1600 kw., 800 volt d-c. generators driven at 712 rpm. by a 4000 hp., 6600 volt induction motor. Runout tables and a cooling bed convey the finished plate through water sprays and the plate shear, and on to the plate warehouse.

This mill produces both sheared and universal plate, and supplies the material for subsequent rolling in the sheet mill. A gravity conveyor transfers the latter material across an open yard to the charging building of the sheet mill.

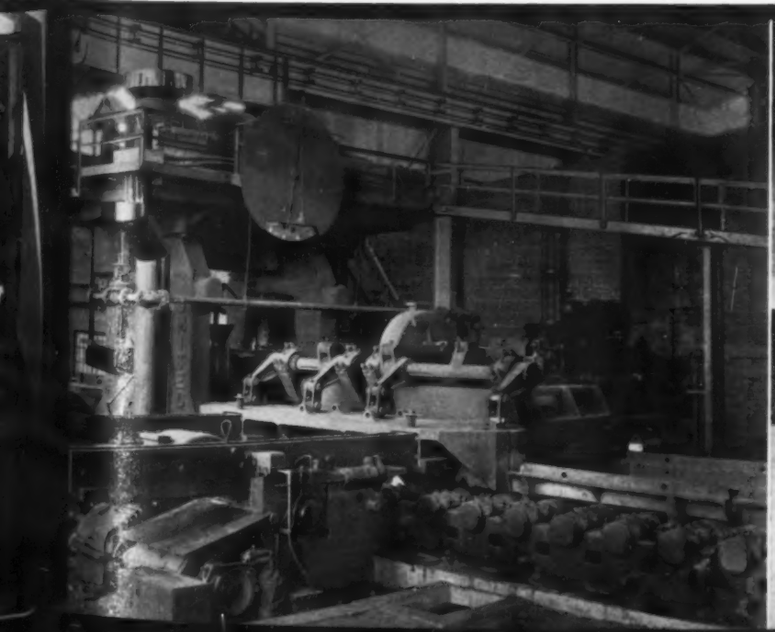
ROD MILL

Four continuous end-charged, end-discharged heating furnaces serve the rod mill. Billets 3⅞ inches square are brought to the charging ends of these furnaces by a conveyor from the billet storage yard. The furnaces are top-fired with natural gas through two high pressure inspirating burners, and have hearths 38 feet 4 inches long by 8 feet 3 inches wide. Active width of the furnace, however, is reduced to 6 feet 9 inches by brick piers along the side walls.

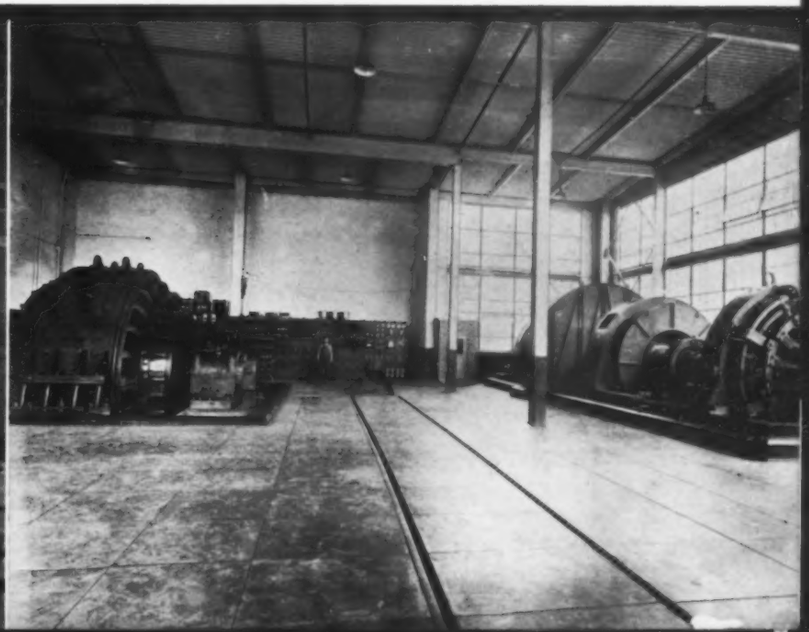
The hot billets leaving the furnaces move over a roller table through a continuous tandem roughing train of seven 16-inch stands. The first six stands are driven through gearing by a single 1750 hp., 514 rpm. synchronous motor, while the seventh stand is driven through a gear unit coupled to a motor-generator set which supplies power to the motor driving the finishing stands, and which consists of a 1000 kw., 250 volt d-c. generator driven at 720 rpm. by a 2100 hp. synchronous motor. The gear unit is designed to transmit 700 hp.

The remainder of the mill follows the Garrett lay-out. No. 8, 9 and 10 stands are 12-inch stands in line, and are driven by a direct connected 1750 hp., 180 rpm. synchronous motor, while a 1300 hp., 257 rpm. synchronous motor drives stands No. 11 and 12. A 2750 hp., 450 rpm. synchronous motor drives the next four stands through multiple spindles with suitable gearing, and the last two finishing stands are driven by a 1200 hp., 520-575 rpm. d-c. motor which receives power from the motor-generator set mentioned above. The use of adjustable speed drive on these stands allows compensation for roll wear in these stands. The last eight stands are all 10-inch.

The synchronous motors are built for 6600 volts, 3-phase, 60 cycles, with 230 volt fields designed for 90 per cent leading power factor at full load. They are started



The 40″ blooming mill runs in composition bearings and is driven by a 7000 hp., 700 volt d-c. motor.



General view of the blooming mill motor-room, showing the motor on the left, with motor-generator set on the right.

directly across the line, with the exception of the 2750 hp. motor which is started through a limiting reactor.

Repeaters are installed between stands No. 8 and 9, No. 10 and 11, No. 12 and 13, No. 14 and 15, and No. 16 and 17. The roughing train is set up for four rolling lines, while the finishers are set up for seven strands. An adjustable speed timer, under the control of the roller, automatically gives a signal to the furnace operators to discharge a billet, so that the flow of material through the mill is rapid and continuous. Maximum delivery speed of the mill is approximately 1880 feet per minute.

All roll necks in the rod mill operate in composition bearings, water-lubricated.

A typical rolling schedule, reducing 3⅞ inches square billets down to No. 5 rod, is as follows:

Pass No.	Average roll diam-inches	Roll rpm.	Area of section sq. in.	Per cent Reduction of area	Speed, ft. per min.
Initial	——	——	14.56	——	——
1	16	39.29	10.23	29.7	164
2	16	37.122	6.81	33.5	146
3	13	27.543	3.25	52.2	96
4	15½	37.122	1.98	39.1	150
5	15½	63.85	1.02	48.4	258
6	17½	87.49	.854	16.3	400
7	16	84.21	.516	39.6	352
8	12	180	.330	36.0	565
9	13½	180	.224	32.2	635
10	13	180	.178	20.5	612
11	11	257	.129	27.5	740
12	12¼	257	.099	23.3	822
13	11	327	.088	11.1	940
14	12¼	327	.0698	20.6	1045
15	11	424	.0583	16.5	1220
16	12½	424	.0457	21.6	1385
17	11	530	.0421	7.9	1520
18	12½	530	.0336	20.2	1735

Leaving the mill, rods are coiled on seven reels, driven by a 75-150 hp., 230 volt, 350-900 rpm. d-c. motor. Coils are then dropped upon a conveyor leading to a transfer track connecting the rod and wire mills.

This mill, producing largely No. 5 rod, averages 35 tons per hour production, and has operated at rates 25 per cent in excess of that figure.

BAR MILL

The bar mill is located in a building which parallels the blooming mill and butts against the billet storage, from which billets are brought to the bar mill furnaces. The mill is served by two continuous furnaces with hearths 45 feet 8 inches long by 10 feet, fired top and bottom with natural gas through three high-pressure inspirating burners in each location. Actuated by the furnace pushers, hot billets drop from the end of the furnace and are conveyed to an 18 inch three-high roughing stand. This stand is driven by an 800 hp., 93 rpm. induction motor. After several roughing passes in this stand, the billet passes on to the finishing stands over mill tables in which is located an up-cut shear.

The finishing stands are located in two groups, the first consisting of five 12-inch stands side by side, and the second of two 9-inch stands. The five 12-inch stands are driven by a single 900-1300 hp., 140-210 rpm. induction motor, while a 400-600 hp., 210-375 rpm. motor drives the two 9-inch stands. Composition bearings are used on all roll necks in the bar mill.

This mill produces small flats, rounds, squares and angles, and has an overall production rate averaging about 15 tons per hour, although this rate may be doubled on good runs of the larger sizes.

Leaving the mill, the bar is carried by the runout table and deposited upon either of two hot-beds of the rocker type, located along either side of the runout. At the lower side of both hot-beds are cold run-out tables leading to the bar shears.

There is another bar mill located in a separate plant in Alabama City, about one-half mile from the main plant. This mill consists of three 20-inch stands and four 13-inch stands. This mill is used for large size bars, particularly flats.

SHEET MILL

One of the later additions to this plant is the sheet mill, which has recently been modernized to a high degree of operating efficiency with a 50 per cent increase in capacity. The mills are arranged in two trains. One includes a jobbing mill, two three-high roughing mills and a two-high finisher, driven by a 1500 hp. induction motor, while the other consists of five two-high finishing stands, driven by an 1800 hp. motor.

The jobbing mill is served by a chain-conveyor type continuous furnace 72 feet long by 7 feet 6 inches wide, fired with coke oven gas or natural gas through two large long flame burners. Five more furnaces of this type, 72 feet long by 5 feet 6 inches wide, together with two double-lane furnaces 55 feet by 5 feet 2 inches, complete the heating facilities for the hot mill. All of these furnaces are in line, with their charging ends placed along the charging building, to which the material is brought from the plate mill by a gravity conveyor.

The three-high roughing mills have been made completely automatic by a system developed in the plant. An automatic timer kicks bars out of the furnace at pre-determined intervals. Bars pass over a table to the mill, where they receive three passes. Pre-set screwdown control is actuated from a flag switch on the exit table, which also controls the tilting table on the exit side. When the screwdown reaches the bottom setting for the last pass, the flag switch is inoperative, and the break-down passes on out and is piled. The entire process is accomplished without any manual control or handling.

The two-high finishing mills are equipped with the conventional mechanical tables and catching equipment.

Sheet finishing equipment includes two rocker-type picklers, each with two acid tanks, and two rinse tanks.

The first rinse tank is a water tank while the second contains an alkaline solution. Annealing facilities include three annealing covers heated by vertical radiant tubes in which natural gas is burned, together with ten in-and-out annealing furnaces, fired with natural or coke oven gas. Light gauge corrugated metal covers are used in the in-and-out type furnaces as well as in the radiant tube covers. Deoxidizing is affected with straight natural gas. Other finishing equipment includes an open annealing furnace which is a duplicate of the heating furnace on the jobbing mill, four stands of cold sheet mills and five sheet galvanizing pots. With the new equipment a complete line of galvanized products, including corrugated, crimped, and rolled roofing and roofing trim materials, may be produced

WIRE PLANT

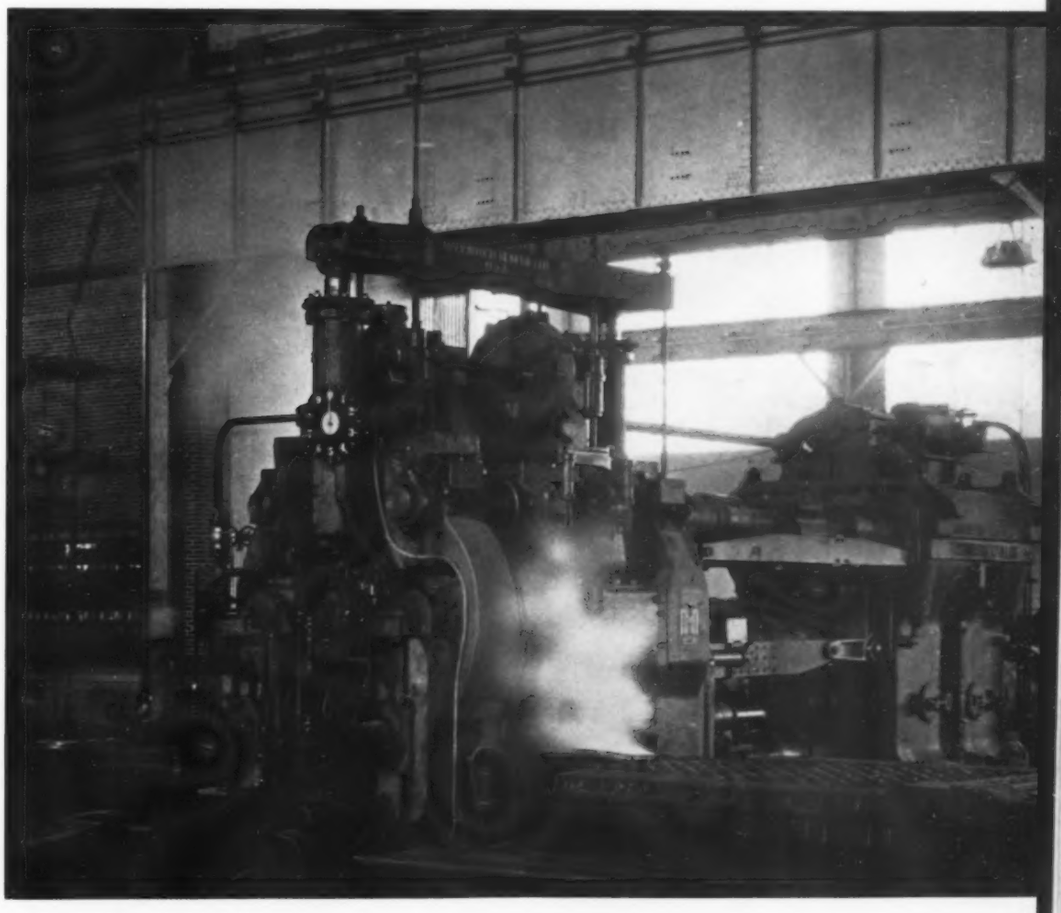
As previously mentioned, coiled rods are brought to the wire plant from the rod mill on narrow-gauge transfer cars. Here the initial process is pickling, which is effected by immersing the coils by jib crane in to an acid tank, followed by a water tank. After pickling, the coils may be subjected to fine sprays of water until slightly coated with a faint rust, or sull, which aids in the drawing process but cannot be used for the brighter finishes on the coarser wires. After this, coils are given a lime dip, loaded on to trucks and placed in the baking ovens, of which there are fifteen, 60 feet long. Here a temperature of 300-400 degrees F. is maintained by natural gas burners.

The main wire drawing department consists of six benches of 40 friction-type single-pass blocks each. Each bench is driven by a 450 hp. synchronous motor. A recent addition to this department are two continuous five-block wire drawing machines of the latest type, which have materially increased the capacity of the department. Adjacent to the main department are 80 blocks arranged on three benches, for drawing the finer gauges.

Coil annealing is effected in eight pot type furnaces fired with natural gas and holding approximately 7000 lb. each. Pots are handled in and out of the furnaces by overhead crane. Concrete pits are provided where pots are placed for cooling after annealing.

Two continuous wire galvanizing units are installed at the end of the drawing department. Each unit consists of two lead pans, an acid tank, a flux bath, a galvanizing pot, and a recoiling frame. The wire is heated to approximately 900 and 1350 degrees F. respectively in the two lead baths, which removes the effects of cold working. After pickling in a solution of hydrochloric acid, the wire passes through the flux and molten spelter, receiving its protective coating. Excess coating is wiped off, the wire cooled and recoiled on take-up reels.

Various wire products are also manufactured in this plant. Adjacent to the wire drawing department is the nail department, housed in two rooms and totaling



The plate mill is a 32″ and 22″ by 90″ unit, equipped with composition bearings, and driven by a 4000 hp., 800 volt d-c. motor.

more than 260 nail machines, all belt-driven from overhead shafting. Tractors handle wire to the machines and nails from the machines. Sixteen rumblers serve to clean and polish the nails, which are produced in sizes from small brads up to spikes one foot long, in many types, and in various finishes for which suitable finishing equipment is provided. Staples are made in a battery of seven machines. There are 17 wire fence machines upon which fencing 26-72 inches wide is woven, with various sized mesh, while barbed wire is produced on 70 machines. These items have formed an important part of the production of this plant from its very inception.

Among the recent additions to this plant is a new bolt and nut plant, equipped to produce a complete line of building, carriage, and machine bolts from 3/16 inch to 1½ inch. Total bolt-making capacity is 1000 tons per month. Present equipment includes eight cold-headers for 3/16—1½ inch stock up to 6 inches long, and eight hot-headers for making 3/8—1½ inch bolts and rivets, as well as the necessary hot and cold trimmers and cutters, hot-press nut machines, burring machines, threading and tapping equipment, and heat treating facilities. It is expected that this department will be further enlarged.

POWER AND FUEL

Electric power for plant operation is partially generated and partially purchased. At the blast furnace plant is located a power plant of excellent design and high operating efficiency. There are four 900 hp. bent-tube boilers, designed for 400 lb. per square inch steam pressure and 250 degrees F. superheat. They may be fired with either blast furnace gas, natural gas, or pulverized coal. In a typical month, the fuel may be made up 70 per cent from blast furnace gas, 25 per cent natural gas, and 5 per cent coal. Gas is burned through pressure burners, while pulverized coal is fired through turbulent-type burners fed by a bin system. A complete system of automatic control is installed.

In the turbine room, which is adjacent to the boiler room there are the two turbo-blowers for the blast furnace, previously described, and two compound turbo-generator units. Each of the latter consists of a high-pressure unit rated at 5000 kva. and designed for steam at 385 pounds pressure, 250 degrees F. superheat, with 3 pounds back pressure, and a low-pressure unit rated at 2500 kva., with 3 pounds steam pressure and 28 inch vacuum. These low-pressure units were formerly used on the exhaust of steam engines driving mills in the plant. Total generating capacity is therefore 15,000 kva., at 6900 volts.

The power plant in general follows central station design, in that all auxiliaries are electrically driven, condensate is used for generator cooling and oil cooling, make-up is distilled in evaporators, feed water is heated to temperatures approximating 300 degrees F., and air preheaters are installed on each boiler.

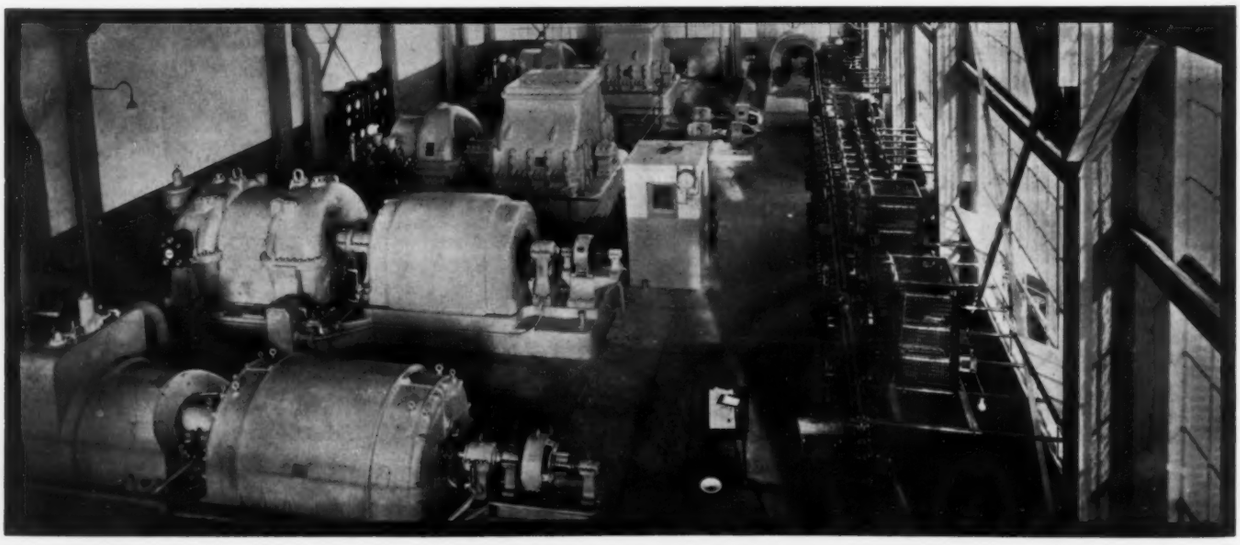
There is also a low pressure boiler house, containing six 375 hp., 125 lb. pressure boilers, fired with coke oven and natural gas, and supplying miscellaneous steam throughout the steel plant. Plans are now proceeding, however, to eliminate this house by the installation of a steam line from the power house steam plant.

Fuel for the entire plant is largely gaseous, being made up of blast furnace gas, coke oven gas and natural gas. In a typical month, the proportions are somewhat as follows:

Surplus coke oven gas	9 per cent
Surplus blast furnace gas	20 per cent
Natural gas	70 per cent
Coal	1 per cent

Surplus coke oven gas is used primarily on the sheet hot mill, and the in-and-out and open annealing furnaces, with the balance going to the open hearth and some dump gas to the boilers. Surplus blast furnace gas is used entirely as boiler fuel, with some coal. Natural gas is distributed to the open hearth, soaking pits, plate, bar, and rod mills, wire plant, sheet mill, nut and bolt department, forge shop and boiler-houses.

The powerhouse includes two turbo-blowers for the blast furnace, shown in the background, and two compound generating units, one of which is shown in the foreground.



COLD MILLS & TIN PL
FAIRFIELD TI
TENNESSEE COAL.
SALVAGE DEPT
FAN ROOM
PALM OIL STORAGE
BOILER ROOM
MACHINE SHOP
TIN SHOP
REMP SYSTEM
TEMPER PASS MILLS
AIR DUCT
SOUTH COLD REDUCTION BUILDING
ANNEALING
TIN MILL FINISHING BUILDING
ALL OTHER TONNAGE DEPARTMENT

, TIN PLATE FINISHING

ELD TIN MILL

COAL, IRON & R.R. CO.

48" HOT STRIP M

FAIRFIELD TIN M

TENNESSEE COAL, IRON

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T STRIP MILL

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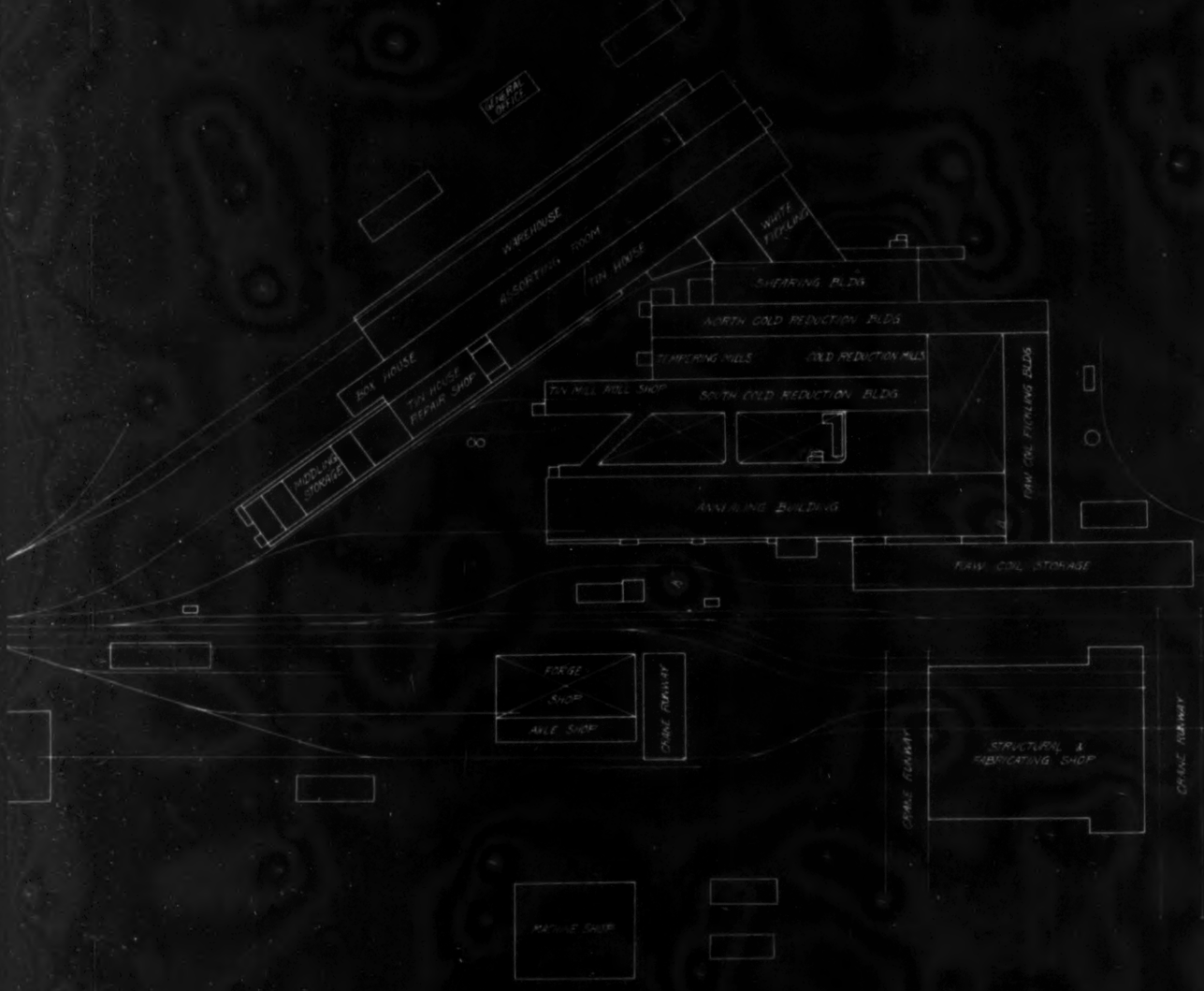
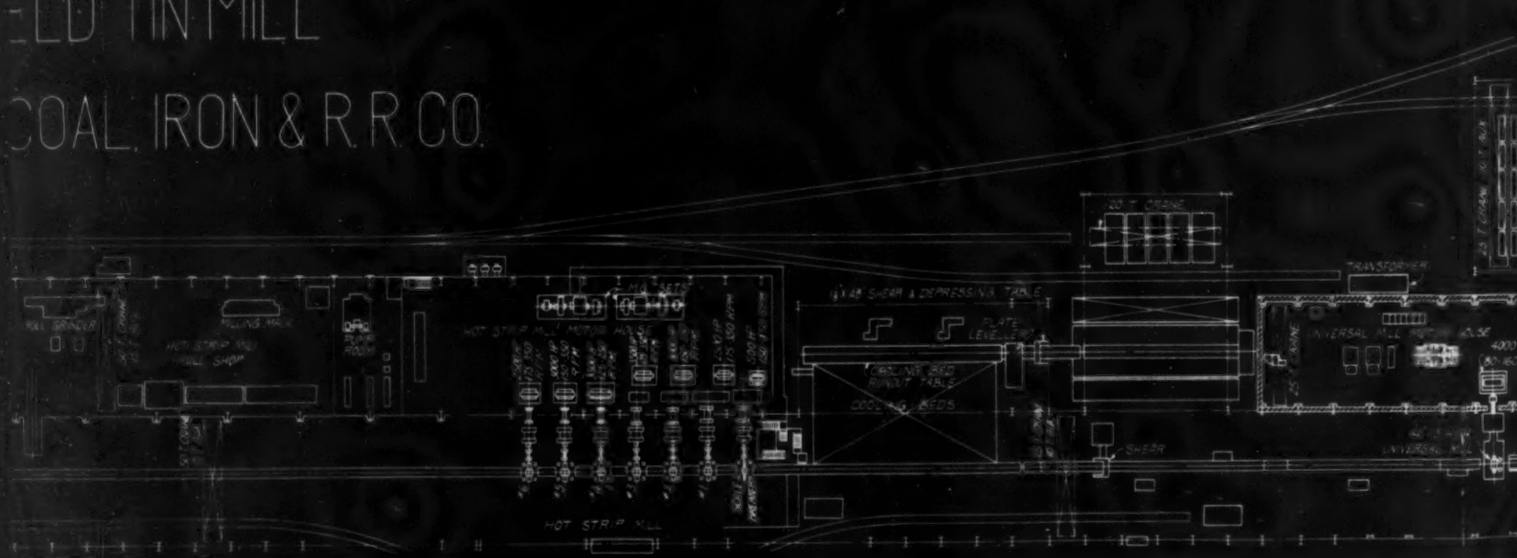
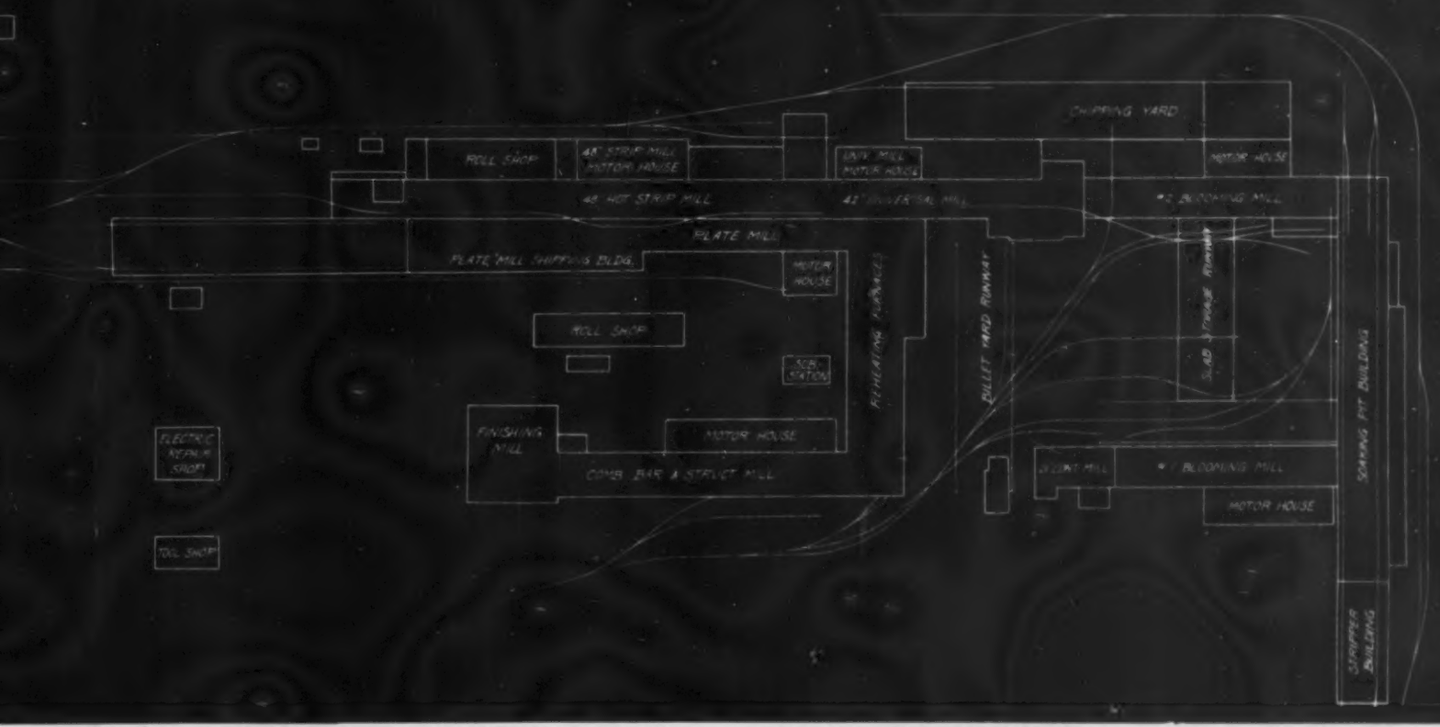
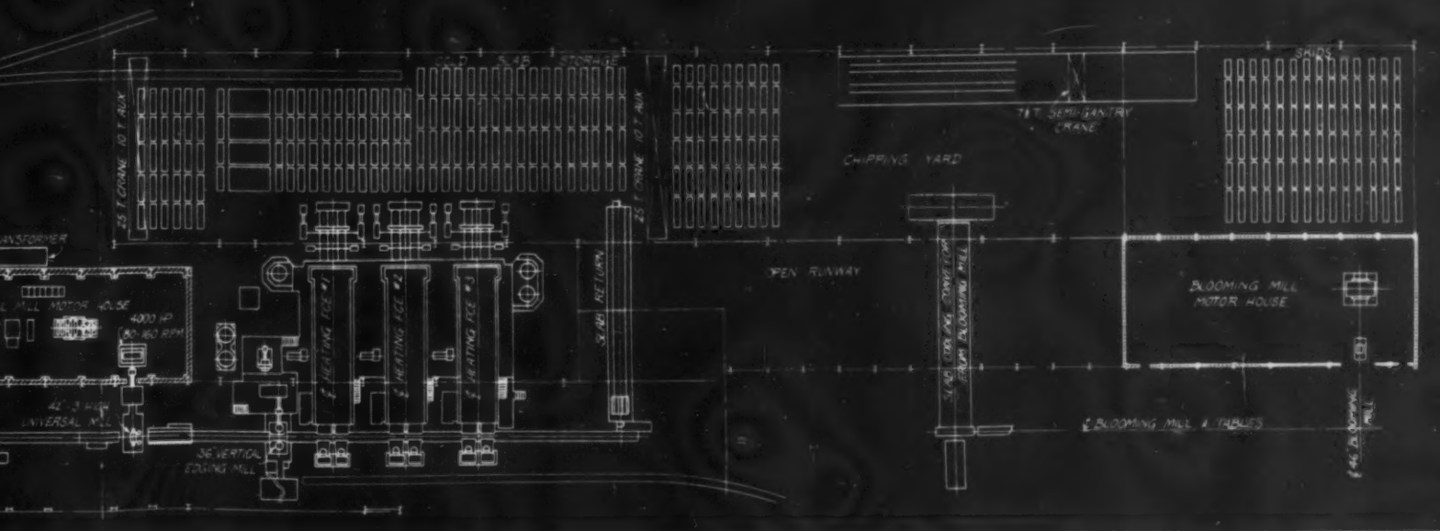
COAL, IRON & R.R. CO.





GENERAL PLAN
FAIRFIELD TIN MILL
TENNESSEE COAL, IRON & R.R. CO.





STEEL INDUSTRY TO PURCHASE NEW EQUIPMENT

Approximately $126,000,000 will be spent by steel companies during 1939 for new construction and equipment, according to reports received by the American Iron and Steel Institute from one hundred and fifty companies representing more than 90 per cent of the industry's capacity. The industry's proposed expenditures for new equipment this year raise the total spent or to be spent for such purposes since 1934 to nearly one billion dollars.

In addition to the expansion programs covered in their estimates for 1939, however, a number of companies indicated that certain additional projects now under consideration might be started in 1939 if the business outlook improves sufficiently.

In 1935 the steel industry's expenditures for new equipment and construction amounted to $140,000,000. In the following year expenditures increased nearly 55 per cent to a total of $216,000,000. In 1937 the amount was $320,000,000 nearly 130 per cent more than the expenditures in 1935 and almost 50 per cent above 1936.

In January 1938, companies in the industry estimated that their contemplated expansion program would involve spending a total of $165,000,000 during 1938, but actual expenditures fell short of that figure by approximately $25,000,000. Modernization of existing equipment is the principal item of the industry's construction program for 1939.

SAFETY SWITCH AND PANELBOARD DESIGNS ANNOUNCED

▲ The "rocker-type" safety switch, a 30-ampere front operated enclosed switch, has a curved molded handle which is rocked by thumb action to "on" or "off" position. Handle and switch mechanism are all one piece, operating on frictionless knife-edge bearings. Provision is made on the handle for marking circuit legend. The switch, manufactured by the Bull Dog Electric Products Company, is of modern streamlined design. Other features are positive action full-floating contacts, screw type wiring terminals, ten well-placed knockouts, and silver-surfaced current-carrying parts.

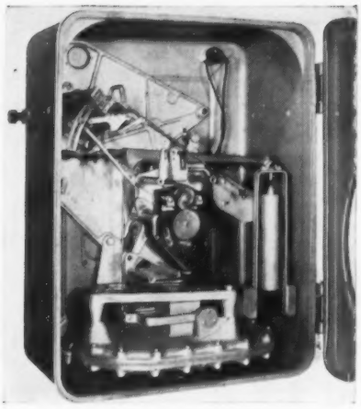
The "rocker-type" panelboards are a companion development to the "rocker-type" switch. The rocker handles make "on" and "off" operation safe, simple, and sure. Circuit name or number can be written on a card inserted in the handles. Panel unit is of porcelain for maximum dielectric strength and resistance to heat.

The curved handle enhances the operation of this safety switch. Circuit legend may be inserted directly on the handle.

IMPROVED DESIGN ON BOILER METER

The development of a diaphragm-operated air flow mechanism for a steam and air flow boiler meter has been announced by the Bailey Meter Company. The use of this mechanism simplifies the application of boiler meters to steam generating units in which high static draft conditions are likely to be encountered. With it, air flow connections may be made at locations in economizers, air heaters, or boilers where high draft conditions preclude the use of the usual oil-sealed air flow mechanism.

The mechanism employs a large diaphragm which is clamped between the flanges of a metal housing. Air flow connections from the boiler are made to this housing on each side of the diaphragm so that changes in differential pressure are measured and recorded in terms of air flow. The diaphragm is made of silk and is coated with a compound which ren-



Changes in differential pressure are recorded in terms of air flow by the diaphragm-operated mechanism for boiler meters.

ders it air tight and impervious to both heat and moisture.

Air supplied to the boiler for combustion is recorded by this mechanism and is coordinated on the boiler meter chart with the record of steam flow. When these records coincide one upon the other on the 12-inch diameter uniformly graduated chart, ideal combustion conditions exist and the boiler operator can see that no adjustments to fuel or air supplies need be made. If the rate of steam flow exceeds the air flow, a deficiency of air is recorded and to restore economical combustion conditions, the operator need only increase the air supply until the pens again coincide.

In addition to recording air flow and steam flow this standard boiler meter may also record flue gas temperature on the same chart along with the other two records. The record of flue gas temperature is distinguished by recording it in green ink, while the steam flow is recorded in red ink, and air flow is in blue ink. The meter is arranged so that the records may cross one another and so that the records of steam flow and air flow may coincide without interference of the recording pens.

STANDARDIZATION OF GENERATING EQUIPMENT RECOMMENDED

▲ With the adoption of recommendations for the standardization of steam turbine generating equipment by the National Defense Power Committee, as part of the general program of speeding up production of power generating machinery, individually designed turbines and generators will be the exception rather than the rule. The expenditure of a large amount of time on engineering and design for each machine will be eliminated. Special design has in large part prevented the adoption of quantity methods of production.

The National Defense Power Committee in a statement issued recently said, "In the past, turbines and generators of these large capacities have been chiefly tailor-made jobs, built to order on special designs prepared by the engineers.

"The subcommittee on standardization, of which Commissioner Basil Manly of the Federal Power Commission is chairman, while establishing these preferred standards, has been careful in its report to provide sufficient latitude for the modification of the standards to meet the special conditions arising in connection with the installation of new equipment in existing plants or where unusual physical conditions must be met.

"Provision is also made for the consideration of technical advances in the art. But in every case where deviation from the preferred standards is suggested the burden of proof will be upon the utility or manufacturer proposing such deviation. The committee will at all times welcome constructive suggestions from the industry."

Deviation from the preferred standards can best be illustrated by the following cases:

1. The temperature of condensing water supply may require turbines designed for operation with back-pressures higher than herein provided.
2. The present availability in manufacturers' plants of turbine-generators well advanced in production points clearly to the completion and use of such equipment.
3. Duplication of a turbine-generator, not currently discontinued by the manufacturer as an active design, may expedite manufacture and installation of power facilities.
4. The manufacture and installation of turbine generators adapted to meet essential requirements in existing stations may facilitate rapid creation of generating capacity.

The accompanying table shows the preferred standards for seventeen sizes of condensing or topping turbine generators from 10,000 to 100,000 kw. rating. The preferred standard generator voltage will be 13,800, but voltages of 11,000, 11,500, 12,000, 13,200, or 14,400 may be furnished and will not be considered special if required to meet the needs of any existing distribution system.

CONDENSING TURBINES

GENERAL: All sizes: Back pressure 1″ or 1½″ Hg. abs.; short circuit ratio 0.9; generator voltage 13,800; excitation voltage 250									
Rating, kw.	10,000	12,500	15,000	20,000	25,000	35,000	50,000	75,000	100,000
Speed, rpm.	3,600	3,600	3,600	3,600	3,600	3,600	3,600	1,800	1,800
Throttle pressure, lb. per sq. in. ga.	650	650	650	850	850	850 or 1,250	850 or 1,250	850 or1,250	850 or 1,25
Throttle temperature, deg. F.	825	825	825	900	900	900	900	900	900
No. of extraction openings	3	3	3	3	3	4	4	4	4
Temp. at extrac. openings 10 deg. F. at rated output	170/225/290	170/225/290	170/225/290	170/225/290	170/225/290	170/225/290/350	170/225/290/350	170/225/290/350	170/225/290/350
Turbine capacity, % of kw. rating	125	125	125	125	125	125	125	125	125
Power factor	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Generator cooling	Air	Air	Air	Air	Air or Hyd.	Hyd.	Hyd.	Hyd.	Hyd.

SUPERPOSED TURBINES

GENERAL: All sizes: 3600 r.p.m.; throttle pressure and temperature 1250 lb./sq. in. ga., 925 deg. F.; back pressure 200–300 lb./sq. in. ga.; short circuit ratio 0.9; generator voltage 13,800; Excitation voltage 250.								
Rating, kw.	10,000	12,500	15,000	20,000	25,000	35,000	50,000	60,000
Turbine capacity, % of kw. rating	111	111	111	111	111	111	111	111
Power factor	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8 or 0.9
Generator cooling	Air	Air	Air	Air	Air or Hyd.	Hyd.	Hyd.	Hyd.

The recommended speed of all superposed turbine generators in the table is 3600 rpm.; the throttle pressure 1250 lb. per sq. in. gauge; throttle temperature 925 degrees F. and the range of back-pressures from 200 to 300 lb. per sq. in. gauge.

CALORIMETER MEASURES HEATING VALUE OF GAS

▲ The complete redesign and improvement of its gas measuring and recording instrument, the Calorimeter, has been announced by Cutler-Hammer, Inc. This instrument consists of a tank unit which continuously determines the calorific value of gas and a recording unit that indicates this value immediately, continuously, and permanently, in terms of Btu., on a highly visible thirty-day chart.

The major improvements in the tank unit result in increased speed and accuracy of response because the gas, through better purging, reaches the combustion chamber more quickly. The integrated interior parts have been redesigned to give longer service. Among these improvements are: underwater parts made of brass; elimination of idler gears; direct-connected motor with rigidly aligned gear trains on a supporting trunnion; non-clogging pump and overflow weirs; oilless bearings on slow-moving parts; and in-built water treatment for prevention of biological growths.

Calorific values of gas, in terms of Btu., can be measured immediately and are permanently recorded on a thirty-day chart by this new meter.

The recording unit has also been redesigned so as to provide greater visability, with increased accuracy and control of adjustments.

HEAVY DUTY MASTER SWITCH

▲ A new type of heavy-duty master switch, for mill and crane controllers, has recently been announced by the Westinghouse Electric and Manufacturing Company. This master switch for a-c. or d-c. control circuits is designed for service on cranes, hoists, bridges, roll and transfer tables, coke pushers and similar applications where easy and positive operation and long life are essential.

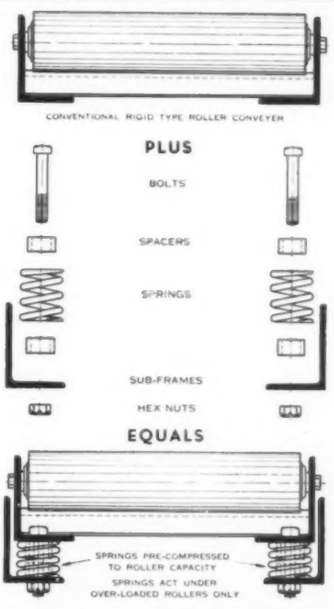
Positive operation results from the cam-opened, spring closed arrangement which eliminates any possibility of contacts remaining closed on a point where they should be open. The switches are easy to operate, and

MATHEWS SPRING MOUNTED CONVEYERS

WHY. . . . . to lower maintenance costs.

WHERE . . . where the service is abusive to rollers, bearings, and axles.

WHEN . . . . for new installations or to replace old equipment.

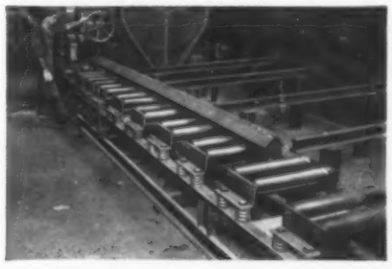


SPRING MOUNTED CONVEYER

Mathews Spring Mounted Conveyers are Protected by United States Patents No. 1,518,836; 2,077,188; 2,077,189; 2,077,190; 2,107,822 and Other Patents Pending.

CAUSE AND EFFECT

THE principle is simple; the roller axles are rigidly locked in the frame as in the conventional "rigid type" construction, but the conveyer frame which retains the rollers is carried on pre-compressed coil springs, the springs held in compression equal to the rated safe load of each roller. Under impact conditions or excessive loads the springs absorb the overload,



In pioneering this development Mathews Engineers have made available to industry nine sizes which cope with the majority of applications.

TYPE 33, Rollers 1⅝", 1.9", 2¼", 2½" diameters, 150 lbs. capacity per roller. **TYPE 53,** Rollers 2⁹⁄₁₆", 3½" diameters, 600 lbs. capacity per roller. **TYPE 58,** Rollers 3½" diameter, 2000 lbs. capacity per roller. **TYPE 63,** Rollers 4¼" diameter, 4000 lbs. capacity per roller. **TYPE 110,** Rollers 5" diameter, 8000 lbs. capacity per roller.

Ask for Data Sheet 24-A & B. It contains complete engineering data. The book "Equipping Industry for Continuous Production" illustrates installations. Both items sent upon request.

MATHEWS CONVEYER COMPANY

144 TENTH STREET, ELLWOOD CITY, PENNA.

CONTINUOUS FLOW PRINCIPLE OF HANDLING MATERIALS

are provided for either hand or foot operation.

Weatherproof construction is maintained by use of cast-iron base and cover with wide flanges. Accessibility for inspection and wiring results from the use of shallow base and deep cover, and group mounting is facilitated by a cover which can be removed vertically. The switches may be mounted either vertically, or horizontally.

CONVERTIBLE AIR CIRCUIT BREAKER

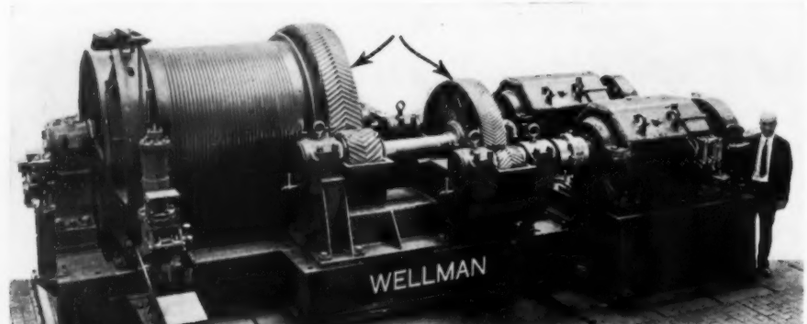
▲ Although applicable to many classes of service the general purpose air circuit breakers (Type ET-20) are intended, primarily, for use as mains in panelboards and for circuit protection of main distribution feeders in switchboards where concentration of power requires a breaker of 20,000 amperes interrupting capacity. The unit, manufactured by I-T-E Circuit Breaker Company, is readily convertible to either front or rear connection.

This general purpose air circuit breaker is safely adaptable for uses where power concentration demands a breaker of 20,000 amperes interrupting capacity.

The poles open and close simultaneously and are operated by a single handle. Each pole is equipped with an inverse time thermal overload and an instantaneous magnetic trip feature, both operating on a common trip so that an overload on any pole opens the breaker. The trip units are interchangeable and are calibrated and contained within a case which is sealed to prevent tampering. The instantaneous trip features are calibrated at six to eight times the rating of the circuit breaker. The breakers are trip free of the handle in any position and cannot be held closed against heavy overloads or short circuits. The handles are dark red bakelite to be distinguished from the standard 600 ampere frame circuit breaker.

NEW MARKING PAINT DEVELOPED

▲ Solidified paint in a stick form has been developed, patented and recently improved by the Markal Company. This paintstick can be used in any weather for marking hot or cold surfaces of sheet, strip, structural steel, galvanized iron and other steel products. It will mark on wet and dry surfaces, defying both weather



Farrel-Sykes Herringbone Gears are used in this single drum, double-motor-driven Blast Furnace Skip Hoist, built by the Wellman Engineering Co., Cleveland.

FARREL-SYKES GEARS
Aid the Performance of this Wellman Skip Hoist

When the Wellman Engineering Company wanted long-wearing, dependable gears for this skip hoist, they selected Farrel-Sykes continuous tooth herringbone gears.

For these gears give never-failing performance under the severest operating conditions and they are exceptionally quiet and smooth-running.

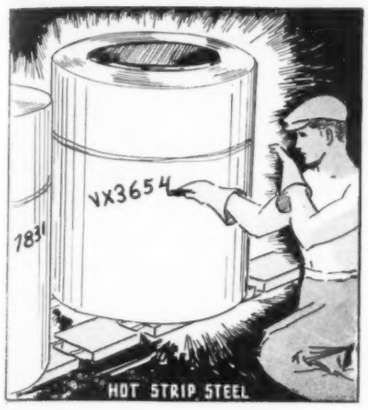
These qualities are derived from their rugged construction, from the extra strength and load-carrying capacity of continuous herringbone teeth, from the accuracy of tooth generation by the famous Sykes process, from the selection of the right materials and from numerous other factors which long experience, engineering resourcefulness and unusual plant facilities enable us to combine and apply to the correct solution of gear drive problems.

Farrel-Sykes Gears and Gear Units are made in any capacity up to 10,000 H.P., for every type of service. A series of standard units offers a wide range of types and sizes for diverse operating conditions. Special units built to order.

Consult our engineers on your gear problems

FARREL-BIRMINGHAM COMPANY, INC.
366 VULCAN STREET BUFFALO, N. Y.

FARREL SYKES GEARS — *The Gear with a Backbone*



The marks produced by this paintstick adhere tenaciously to the surface under all conditions.

and time. The mark dries like liquid paint having all the characteristics of paint. Each unit package of twelve is supplied with a metal polished holder. The paintsticks are available in colors of red, white, green, yellow, black, and blue.

The material for marking hot surfaces is suitable for use in temperatures from 200 to 1800 degrees F. It will not run, or discolor, while hot or come off after cooling. It does not chip, peel or crack. The marks produced on hot metal adhere tenaciously to the surface under all conditions. The hot billet or metal sheet may be immersed into water immediately after marking and yet the marks will not be defaced in any way whatsoever. This material is also supplied in a stick form, accompanied by a hard wood holder.

NEW LITERATURE

▲ Harnischfeger Corporation has issued two new catalogues on crane equipment and control. The first is entitled: "Electrical Equipment for Cranes" which should be of singular interest to every overhead traveling crane user. This book, said to be the most complete of its type ever published, tells the whole story of the entire electrical equipment necessary for modern crane operation. It covers thoroughly a-c. and d-c. crane motors of all types, hoist motors, mill-type and heavy-duty d-c. mill motors as well. It also describes the design and application of solenoid operated brakes, thrustor-operated brakes, and goes on to illustrate the many types of manual drum controllers, with speed regulation curves for both d-c. and a-c. operation. Plant superintendents and crane supervisors will be interested in the description of full magnetic regenerative control, counter-torque hoist control, and full magnetic d-c. and a-c. control, as well as the modern types of protective panels, limit switches, limit stops, main line current collectors, crane bridge current conductors, etc.

The second book entitled: "Industrial Cranes" covers completely the design and application of P and H industrial cranes for general usage in all industries. It describes the standard type crane, standard open and enclosed cabs, standard trolleys, load blocks, limited head-room cranes and trolleys, etc. Clearance dimensions, hoists, trolley and bridge traverse speeds are included to supply all the facts about each unit.

These bulletins are numbered, respectively, C-5 and C-6. Copies may

Two draft values, two pressure values, two differential values, or a combination of any two of these three values may be recorded. Hays Draft Recorders are sensitive enough to register accurately increments of .0025 inches water yet are built husky enough to withstand the jars and dirt of steel mill operations.

ACCURATE RECORDING OF

DRAFT, PRESSURE, DIFFERENTIAL

The open hearth furnace is a very leaky structure at best. Therefore, draft conditions within the furnace are apt to be variable. The only way to prevent large leakage of gases is to maintain balanced draft conditions in the hearth.

The *Hays Series OT Supersensitive Draft Recorders* keep an accurate record of draft, pressure or differential—knowledge very essential to effective furnace operation. By connecting the instrument with the risers from the checker chambers to the furnace at a point just above the level of the charging floor a permanent record is made of pressures and drafts at these points. Balanced conditions on each end can be readily obtained and the amount of this draft is an indication of the draft on the bath.

Write for detailed information to 955 Eighth Avenue, Michigan City

The HAYS CORPORATION
SINCE 1901 COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY, INDIANA, U.S.A.

be obtained by writing the Harnischfeger Corporation, 400 West Madison Street, Chicago, Illinois.

▲ Johnson Bronze Company has published a 72-page book describing in detail the service that company renders to bearing users. Information on bronze bearing alloys, tolerance and large range of sizes have been listed progressively. Other features of this new booklet are special sections on oil grooving, flanged bearings and bushings.

Readers desiring to receive this catalogue (No. 390) on sleeve-type bearings, should write to the Johnson Bronze Company, New Castle, Pennsylvania.

▲ Link-Belt Company has recently issued a bulletin on its Peck overlapping pivoted bucket carrier for the economical handling, elevating, and conveying of coal, ashes, stone, cement clinker, and other materials. The buckets of this carrier are pivotably suspended between two strands of chain, thus always being in an upright position except when they are being discharged by automatic dumper. This permits a single carrier to carry the material horizontally, vertically and again horizontally. The machine is slow moving, requiring but minimum power, and has been popularly used in power plants, for handling both coal and ashes in the one machine.

A copy of the new book No. 1720 may be obtained by addressing Link-Belt Company, 307 North Michigan Avenue, Chicago, Illinois.

▲ I-T-E Circuit Breaker Company, Nineteenth and Hamilton Streets, Philadelphia, Pennsylvania, has available for distribution the following publications:

Bulletin No. 938: "Logan Auxiliaries Have 2300-Volt Air Breakers" Written by Philip Sporn, vice-president and chief engineer of American Gas and Electric Service Corporation, New York. Gives connection system, test data and oscillogram records of the 2300-volt air breakers installed in the Appalachian Electric Power Company plant at Logan, West Virginia.

▲ Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania, has published the following new catalogues:

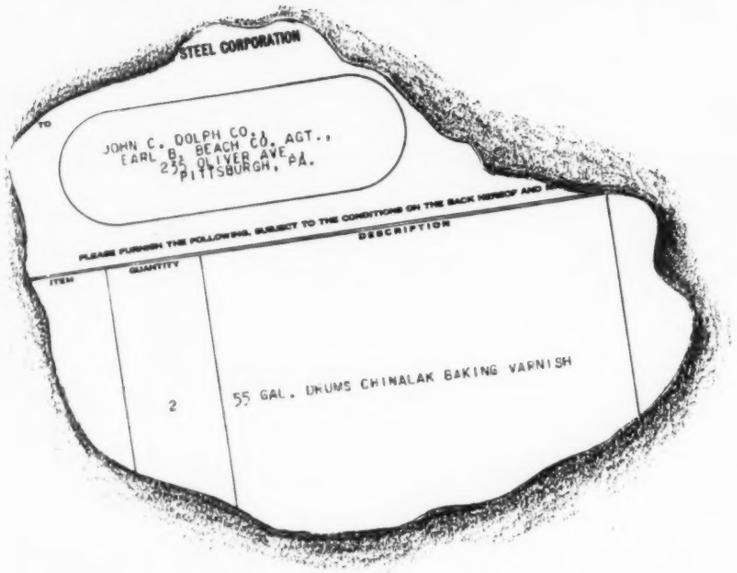
Bulletin 2165: Type SU induction feeder voltage regulator combining low first cost and low maintenance costs is discussed. This regulator is supplied for correcting voltages on single-phase feeders or in banks on polyphase feeders.

Descriptive Data 11-200: Describes the new non-reversing linestarters for squirrel-cage and wound-rotor motors. Typical application of the Type F linestarters include pumps compressors, fans and blowers or any application requiring pushbutton or remote control where across-the-line starting is permissible.

Descriptive Data 29-080: Describes "De-ion" air circuit breakers, primarily intended for circuit protection of main distribution feeders in central stations, industrial plants, or building equipment where heavy concentration of power requires a breaker of 20,000-ampere interrupting capacity. The breakers are available in wire-size ratings from 70 to 600 amperes, and for voltages up to and including 600 volts a-c. or 250 volts d-c.

36 42 46 49

DRUMS OF CHINALAK



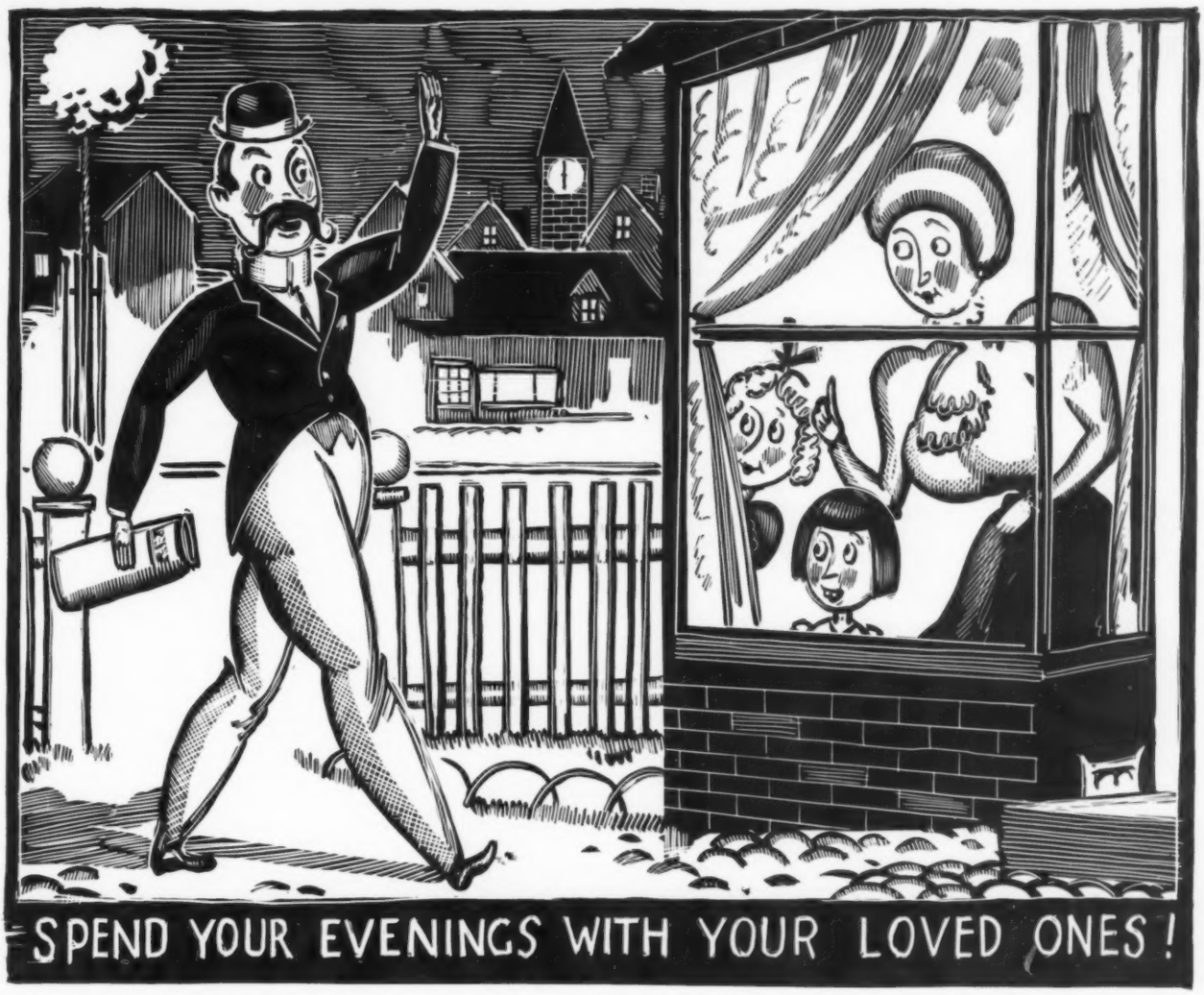
In the past five years, this prominent steel company has ordered 49 drums of CHINALAK Black Baking Varnish as well as 3335 gallons of other DOLPH Products. Such repeat business endorses our claims for our insulating varnishes.

CHINALAK may not be the solution to your electrical maintenance problem but whatever your requirements may be, there is a grade in the DOLPH Line to meet your needs exactly. The JOHN C. DOLPH COMPANY has served the steel industry for many years and would welcome an opportunity to cooperate with your engineers to assist in the solution of any problem relative to the insulation of electrical equipment.

JOHN C. DOLPH CO.

Insulation Specialists

166A Emmett Street Newark, N. J.



HENRY used to throw his pliers at anyone who wistfully whistled "Home Sweet Home" when he was working almost every night rewiring faulty circuits. Now he swings it on the way to supper and enjoys evenings at home, because the "Ten Tested Rockbestos Values" solved his overtime problem.

You may not operate a night shift on electrical maintenance, but don't forget that any single production delay caused by wire-failure may carry a loss that far exceeds the entire cost of proper wiring. Rockbestos users testified to this when they endorsed the ten tested values with these remarks: "No periodic replacement just when attention is needed elsewhere—" "Lowers our production costs by preventing shutdowns." "Rockbestos . . . the answer to a maintenance man's prayer." These unsolicited statements and many others were received from men who are convinced that Rockbestos saves money in reducing maintenance expense and keeping up production schedules . . . perhaps it can do the same for you.

Take an inventory of your money-wasting circuits, check the trouble-causes against the "Ten Tested Rockbestos Values" and let our engineers help you with your problem. For information, samples or a catalog, write to Rockbestos Products Corporation, 915 Nicoll Street, New Haven, Connecticut.

TEN TESTED ROCKBESTOS VALUES

1. Heatproof
2. Fireproof
3. Permanent
4. Lower maintenance cost
5. Resists heat and vibration
6. Saves work
7. Oil and Greaseproof
8. High overload capacity
9. Permanently flexible
10. Greater carrying capacity

Also refer to Electrical World Buyer's Reference

ITEMS OF INTEREST

Leonard Larson has been named chief engineer of the Cleveland district, Republic Steel Corporation, Cleveland, Ohio. Mr. Larson has been associated with Republic and its predecessors for the past twenty-two years. A native of Pittsburgh, he attended Carnegie Institute of Technology and in 1917 went to work for the Central Steel Company in Massillon, Ohio. He was appointed chief engineer of the Central Alloy Steel Company at Canton, Ohio, ten years ago. Mr. Larson is an active member of the Association of Iron and Steel Engineers.

R. H. Bahney was appointed chief engineer of the Central Alloy district of Republic Steel Corporation at Canton, Ohio, succeeding Leonard Larson. Mr. Bahney was employed as a wireman's helper on a line gang at the Central Steel Company plant during the summer of 1915, and following his graduation from Cornell University in 1917 was employed as a clerk in the electrical offices of that plant. He served successively as assistant chief electrician and chief electrician going to Canton as chief electrician with the Central Alloy Steel Company in 1926. He became assistant superintendent of mechanical and electrical departments for the Canton division of Republic Steel in 1931, and was transferred to the engineering department as electrical engineer in 1936. Mr. Bahney is an active member of the Association of Iron and Steel Engineers.

W. D. Falkenstein has been appointed district manager of the Pittsburgh office of the Electric Controller and Manufacturing Company, succeeding A. C. Dyer who is now general sales manager for the company. After serving in the United States Navy during the World War, Mr. Falkenstein returned to Carnegie Institute of Technology and graduated in 1921. While attending school, and during vacation periods, he was employed at the National Tube Company, McKeesport, Pennsylvania. After graduation he went to work for the Duquesne Light Company in Pittsburgh. In 1923, he joined the Electric Controller and Manufacturing Company organization, working in the Pittsburgh district. Mr. Falkenstein is an associate member of the Association of Iron and Steel Engineers.

Kent Harrison has been made assistant to the general superintendent of the American Rolling Mill Company, Butler, Pennsylvania. Mr. Harrison has been open hearth consultant at the Middletown, Ohio, plant of the American Rolling Mill Company. Prior to this he was open hearth superintendent at Colorado Fuel and Iron Corporation, Pueblo, Colorado.

The following appointments were made by the Tennessee Coal, Iron and Railroad Company's coal mining department in the engineering division, Pratt City Station, Alabama.

Birger Thele, formerly testing engineer in the chief electrical engineer's office, was promoted to electrical engineer, coal mines. Mr. Thele is secretary of the Birmingham district of the Association of Iron and Steel Engineers;

Woods G. Talman has been promoted from engineer assistant to industrial engineer, coal mines;

J. C. Kelley, Jr. was appointed property engineer. Mr. Kelley was formerly transitman.

Gordon Fox vice-president, Freyn Engineering Company, recently sailed for Holland in connection with services being rendered by Freyn Engineering Company to the Royal Dutch Blast Furnace and Steel Works at Ymuiden. This company which owns three Freyn blast furnaces, is now adding open hearth and rolling mill departments.

LEONARD LARSON

R. H. BAHNEY

W. D. FALKENSTEIN

Malcolm W. Reed formerly vice-president in charge of operations for the American Steel and Wire Company, has been appointed chief engineer for Carnegie-Illinois Steel Corporation, Pittsburgh, Pennsylvania. Mr. Reed graduated from the United States Naval Academy with a bachelor of science degree in 1916, and in October of that same year entered the employ of the Steel and Wire Company as a rope wire tester at the North Works, Worcester, Massachusetts. He progressively moved to higher positions with the company until September, 1917, when he was made wire rope engineer which position he held until he was made foreman of the rope mill at New Haven, Connecticut, in 1919. Before being transferred back to Worcester, Massachusetts, as assistant district manager in 1928, he was first made superintendent of the New Haven plant. In 1932 he was transferred to Cleveland as chief engineer of the company; in 1933 assistant to vice-president and chief engineer; and in January, 1937, vice-president in charge of operations.

Sydney Dillon who has been chief engineer of the Carnegie-Illinois Steel Corporation, was moved to the office of the chief engineer of the United States Steel Corporation of Delaware. Mr. Dillon was born in Altoona, Pennsylvania, June 21, 1877, and attended the public schools at Braddock, Pennsylvania. At the age of 12, he began working as a messenger and mail boy at the Edgar Thomson Works of the Carnegie Steel Company. A year later he entered the plant's engineering department as a blueprint boy. Acquiring technical training, Mr. Dillon subsequently became a tracer, draftsman and assistant chief engineer.

Mr. Dillon was appointed chief engineer of Edgar Thomson Works in December, 1901, and served in that position for fifteen years. In November, 1916, he was appointed chief mechanical engineer of Carnegie Steel Company, and continued in that position until his appointment as assistant to vice-president of the company in September, 1930. Upon formation of the Carnegie-Illinois Steel Corporation, Mr. Dillon was named chief engineer.

Julius E. Graf assistant chief engineer of the Carnegie-Illinois Steel Corporation, has joined the Treadwell Engineering Company, Easton, Pennsylvania, as vice-president in charge of engineering. Mr. Graf, who has been with subsidiaries of the United States Steel Corporation for twenty-eight years, began with the American Sheet and Tin Plate Company, and at the time of the merger with Carnegie-Illinois Steel Corporation, was chief engineer of the American Sheet and Tin Plate Company. While with the Carnegie-Illinois Steel Corporation he was in an engineering advisory capacity, principally in connection with major projects such as the slabbing mill at Edgar Thomson Works, Braddock, Pennsylvania, and the new Irvin plant, Dravosburg, Pennsylvania. His offices for the time being will be in the Farmers Bank Building, Pittsburgh, Pennsylvania.

James E. Bevan has been appointed assistant chief engineer of the Roller-Smith Company, Bethlehem, Pennsylvania. After graduating from Lehigh University in 1925 with a degree in electrical engineering, Mr. Bevan was employed in the maintenance department of the Bethlehem plant of the Bethleham Steel Company. Mr. Bevan, who until this appointment was switchgear specialist with the Roller-Smith Company, has had experience in maintenance, plant efficiency, and other phases of engineering.

William S. Unger formerly general superintendent of the Pencoyd, Pennsylvania, works of the Carnegie-Illinois Steel Corporation, has been appointed general superintendent of the Lorain division in Johnstown, Pennsylvania. Mr. Unger, is a son of Dr. John S. Unger, retired, for years the manager of the research bureau of Carnegie Steel Company.

Mr. Unger was born at Braddock, Pennsylvania, May 30, 1893, and was graduated from Cornell University in 1916 with the degree of mechanical engineer. He began his industrial career at the Carrie blast furnace of Carnegie Steel Company in 1916 as a student, and later was with the Home-

(Please turn to page 72)

MALCOLM W. REED

SYDNEY DILLON

JULIUS E. GRAF

HOW 54" COLD STRIP REVERSING MILL

Keeps Production Rolling!

Large Steel Company Gets Steady Production at Low Operating Costs With Allis-Chalmers Lo-Maintenance Motors! Get the Facts on Full-Measure Protection in Lo-Maintenance Motors ... on the Savings It Means In Your Mill!

UNDIVIDED RESPONSIBILITY PAYS A BIG DIVIDEND for this steel company on their 4-high cold strip reversing mill! For the main drive equipment on this 54 inch mill—3500 hp main roll motor, two 1750 hp reel motors, 4100 kw motor-generator set consisting of main generator, booster generator, exciter and synchronous motor with complete automatic control—is all made by Allis-Chalmers.

Driving the machines that handle 14,000 pounds of 50 inch sheets of steel at 1200 feet per minute . . . that reduce this vast bulk of metal down to size and gauge so that the dimensions, surface and quality meet rigid requirements . . . that's a big job for any motor!

But that's the kind of job Allis-Chalmers Lo-Maintenance Motors are doing driving a 54 inch, 4-high, cold strip reversing mill! For this steel company knew from experience that this famous line of heavy duty motors combined the sturdiness and accuracy necessary to keep production rolling in one of their plants.

Long Life Motors!

And they knew about the welded steel frame . . . sturdy rotor and stator . . . husky all-around construction with no skimping on materials that add up to give you a motor that's built for long life!

That's the job Allis-Chalmers Lo-Maintenance Motors are doing for this steel company! And that's the job they'll do for you! When you buy a Lo-Maintenance Motor, you get the benefits of the background of Allis-Chalmers' 90 years of advancing with industry . . . the Full-Measure Protection built into every Lo-Maintenance Motor . . . that pays you a dividend in the money you save!

Get all the facts! Call the nearest Allis-Chalmers District Office or write direct to Allis-Chalmers. Find out how you can cut maintenance costs . . . keep production rolling with Allis-Chalmers Lo-Maintenance Motors!

1067

ELECTRICAL DIVISION
ALLIS-CHALMERS
MILWAUKEE·WISCONSIN

H. B. JORDAN

WILLIAM L. DITGES

C. J. SMITH

Harvey B. Jordan has been appointed vice-president of the American Steel and Wire Company, subsidiary of the United States Steel Corporation. Mr. Jordan will be in charge of operations and succeeds M. W. Reed, who has been made chief engineer for Carnegie-Illinois Steel Corporation, another United States Steel subsidiary.

Mr. Jordan was born in Lansing, Michigan, on July 21, 1895. He attended the public schools of San Diego, California, and New Castle, Pennsylvania, before matriculating at Penn State College, where he majored in industrial engineering.

Mr. Jordan was first employed by the American Steel and Wire Company during the summer vacation of 1914 as a chemist at Central Furnaces and Docks in Cleveland. In June, 1915, he was placed permanently with the company, being employed as clean up foreman at the same plant. He worked his way up through the ranks to the positions of first general foreman and then assistant superintendent, being made superintendent of the plant in April, 1929.

In May, 1933, Mr. Jordan was transferred to the vice-president's office, where he did field work and in February of the following year he was promoted to the managership of the metallurgical department, which position he held until being made manager of the Cleveland district in December, 1935. In January, 1937, he was named assistant vice-president.

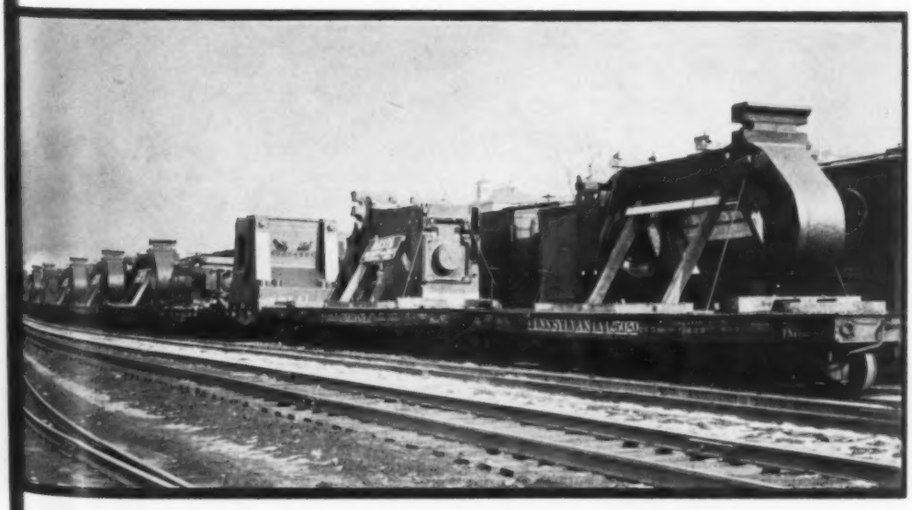
William L. Ditges has been appointed chief engineer of the Morgan Engineering Company, Alliance, Ohio. Mr. Ditges has been identified with the steel industry in various capacities since graduation from college, having been employed in the engineering departments of both Carnegie Steel Company and Bethlehem Steel Company.

In 1916 he joined the engineering staff of Mackintosh-Hemphill Company, advancing successively to the positions of chief engineer and vice-president in charge of design of rolling mills and auxiliary rolling mill machinery. For the last four years he has been connected with the Mesta Machine Company. Mr. Ditges is an Associate Member of the Association of Iron and Steel Engineers.

C. J. Smith who has been head of the maintenance department, Gary Works, Carnegie-Illinois Steel Corporation, since May, 1936, will now be in charge of the maintenance division of this plant. Maintenance in the plant formerly was on a departmental rather than a divisional basis. The new supervisory staff, all of whom are Gary Works employees with considerable service, will be headed by Mr. Smith.

HOT AND COLD STRIP MILL STARTS JOURNEY TO ENGLAND

One of three trainloads carrying only a part of the equipment for a complete hot and cold wide strip mill from the Mesta Machine Company plant at West Homestead, Pittsburgh, to an eastern seaport. An entire ocean freighter will be required to transport this shipment to Shotten, Chester, England, where it will be erected for John Summers and Sons, Ltd., one of the leading English steel producers.



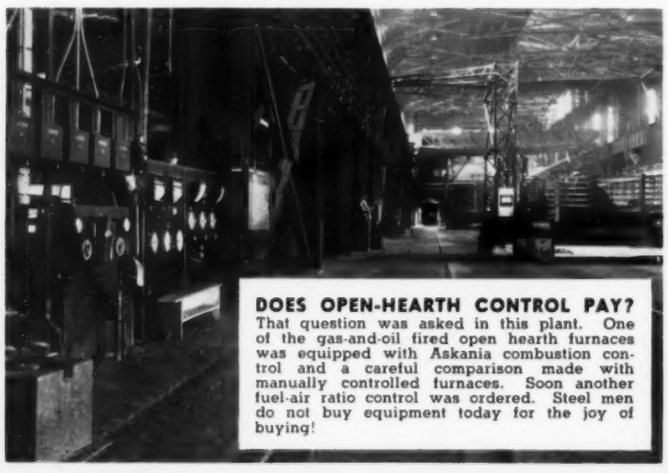
stead works. During the World War he was an ensign in the navy aviation corps.

Returning to Pittsburgh after the armistice, he first served with the Duquesne blast furnaces of the Carnegie company and later with the Clairton stacks. In 1924 he returned to the Carrie furnaces as assistant blast furnace superintendent and in 1928 was named superintendent. He became assistant superintendent of the Homestead works in 1930, and in 1937 he was named general superintendent of the Pencoyd works.

The following changes have been made by the Cochrane Corporation, 17th Street and Allegheny Avenue, Philadelphia, Pennsylvania:

O. H. Woolford
was appointed sales manager for specialties and meters;

A. B. Wallem
after serving Cochrane for over thirty years in various responsible positions, has been appointed specialties consultant.



DOES OPEN-HEARTH CONTROL PAY?
That question was asked in this plant. One of the gas-and-oil fired open hearth furnaces was equipped with Askania combustion control and a careful comparison made with manually controlled furnaces. Soon another fuel-air ratio control was ordered. Steel men do not buy equipment today for the joy of buying!

What are THE FACTS ABOUT COMBUSTION CONTROL FOR OPEN HEARTH FURNACES?

DOES combustion control pay for open hearth furnaces? The best answer is found in the growing trend to combustion control. Just what the fuel economies and production gains are, depends on just what factors are considered and the furnace performance previous to the combustion control installation. But—

—This much is certain. All engineers operating open-hearth furnaces with ASKANIA combustion control do report savings, and all agree that the operating advantages of combustion controls would easily justify the installation even if only small fuel savings were effected. Where ASKANIA *fuel-air ratio control* together with ASKANIA furnace pressure control has been installed, charging time is shortened, tap-to-tap time is reduced, delays per heat are lessened; refractory costs are lowered. Moreover, the uniformly maintained pressure and atmosphere assure even temperature throughout the furnace.

Where constant heat input of mixed fuels is required, ASKANIA combustion control is nothing short of indispensable for the open-hearth furnace. Isn't this growing trend to open-hearth combustion control worthy of your consideration?

ASKANIA REGULATOR COMPANY
1603 S. Michigan Avenue, Chicago, Ill.

ASKANIA CHICAGO *Automatic* CONTROL
"IF IT CAN BE MEASURED—WE CAN CONTROL IT"

Obituaries

S. N. Roberts
mechanical and electrical superintendent of the Atlantic Steel Company, Atlanta, Georgia, died January 28. Mr. Roberts graduated as an electrical engineer from Georgia Tech in 1906, and spent some time with Westinghouse as a student engineer.

In 1908 he was employed by Southern Iron and Steel Company, now Republic Steel Corporation, in Alabama City, Alabama, and was concerned with redesigning and rebuilding electrical equipment. The next year he went with the United States Cast Iron Pipe and Foundry Company in Anniston, Alabama, as plant engineer.

S. N. ROBERTS

Late in 1910, Mr. Roberts joined the Atlantic Steel Company as chief electrician. He was made night superintendent of the plant in 1916 and served in that capacity until termination of the World War made the job unnecessary. He then became electrical superintendent and steam engineer, and in 1920 was made mechanical and electrical superintendent. He had been an active member of the Association of Iron and Steel Engineers since 1923.

Emanuel J. Block
vice-president and a director of the Inland Steel Company, Chicago, Illinois, died on March 6, in Phoenix, Arizona. Mr. Block who was 57 years old, joined the Inland Steel Company in 1901. He was made vice-president in 1919, and for a number of years has been in charge of purchasing.